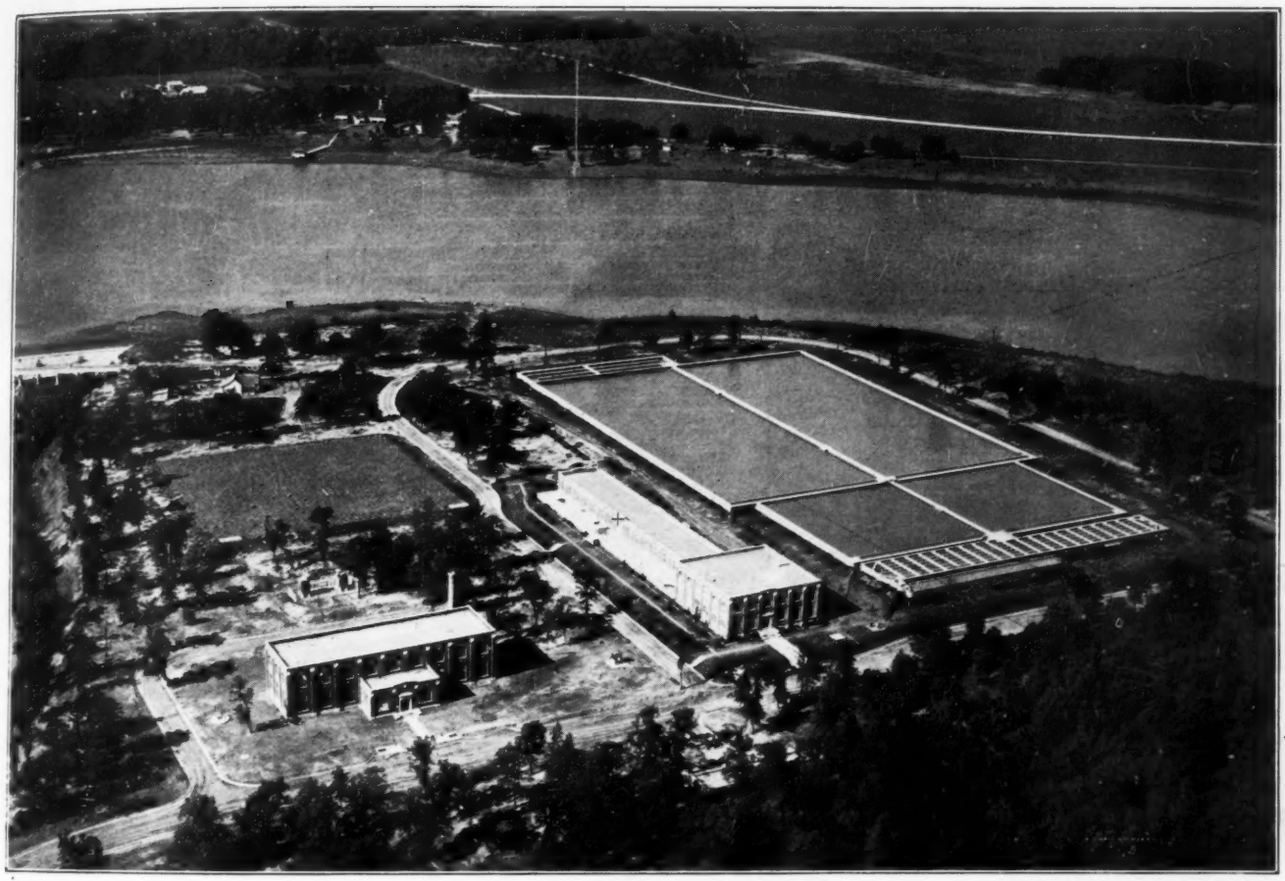
WATER WORKS AND SEWERAGE

March, 1934 — Editor — Vol. LXXXI. No. 3



Bachman Filtration Plant and Pumping Station (Left) Dallas, Texas. (Morey and Morey, Engineers).

PHOTO BY FAIRCHILD AERIAL SURVEYS

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Chlorination in Sewage Treatment
A Self-Liquidating Water Plant Improvement
New Water Purification Plant at Ottumwa, Ia.
Experiences with Chlorinated Copperas as a Coagulant
Operation of Pruss Pump at Baltimore Sewage Works
Performance of Dearborn's Chemical Sewage Treatment Plant

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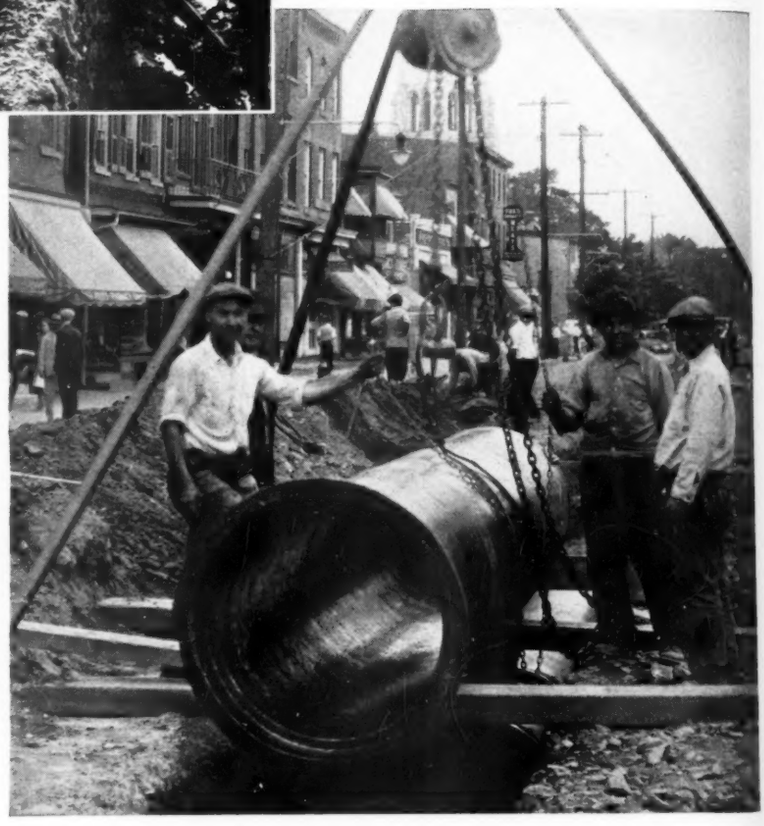

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L. H. ENSLOW, Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues:

N. T. Veatch, Jr., Consulting Engineer, Kansas City, Mo., will discuss values to be recovered from "The Utilization of Sewage" and the by-products of sewage treatment. The most recent development is the plant designed in Mr. Veatch's office for Herington, Kansas, the financing being based on income from the sale of effluent for industrial usage by a railroad.

Richard H. Ellis, Water Commissioner and Superintendent Water Works, Newton, Mass., will describe what is believed to be the most modernized and efficient meter shop arrangement and meter repair and maintenance practice in the East. His article will be of particular interest to Superintendents.

Dr. H. Bach, Chief Chemist, Emscher River Board, Essen, Germany, relates a novel method of treating water by passage through metallic magnesium turnings for the purpose of dechlorinating or deacidification of corrosive waters, by complete CO_2 removal and pH adjustment.

P. S. Wilson, Consultant in Water Works Operation, Glen Ridge, N. J., will contribute a series of short articles dealing with practical devices, simplified calculations and short-cuts useful in maintenance and operation of water works systems.

Frank C. Roe, Engineer of the Carborundum Company, Niagara Falls, N. Y., will describe methods of "Installing, Cleaning and Servicing Porous Air Diffusers" which have proved to be satisfactory practice at sewage treatment plants.

A. S. Behrman, Chemical Director, International Filter Company, is to discuss modern methods of water softening and relate "Recent Developments in Municipal Water Softening."

Dario Travaini, Supt., Sewage Treatment Works, Phoenix, Ariz., will relate experiences with the ill effects of supernatant liquor from sludge digesters and describe a practical scheme of correcting this difficulty and attendant odor nuisance, involving sludge concentration prior to delivery to the digesters.

Marsden C. Smith, Engineer of Water Supply, Richmond, Va., will set forth certain "Opinions Formed as the Result of Filter Sand Studies" conducted at the Richmond filtration plant during the past 3 years.

Darwin W. Townsend, Consulting Engineer, Milwaukee Sewerage Commission, will contribute an article covering operating experiences and costs of centrifugal dewatering and incineration of screenings and grit at Milwaukee.

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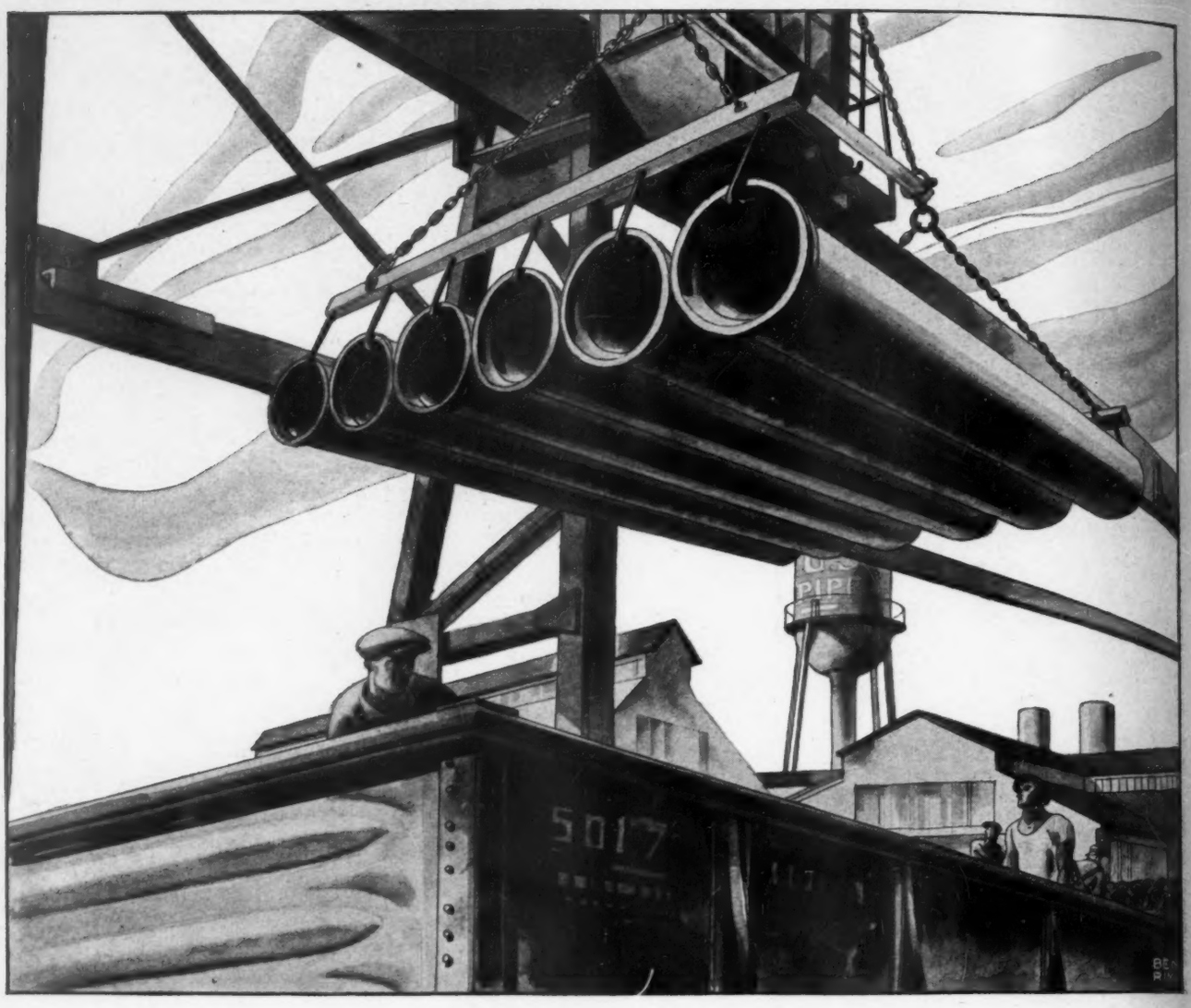

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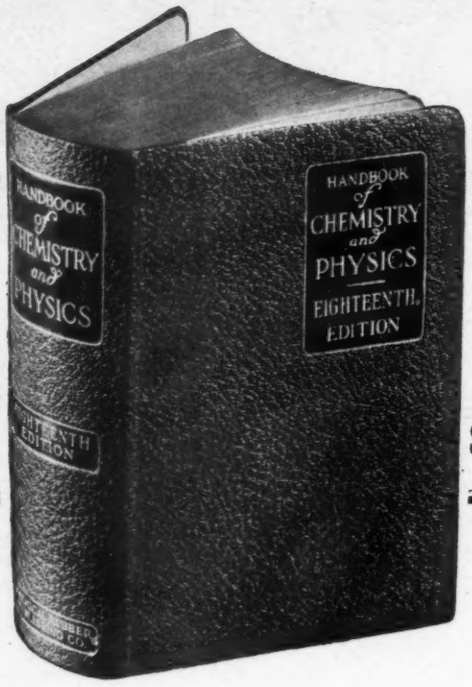

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Report of the Committee on Sewage Disposal of the Engineering Section

American Public Health Association

presented at the Sixty-second Annual Meeting at Indianapolis, October 10, 1933

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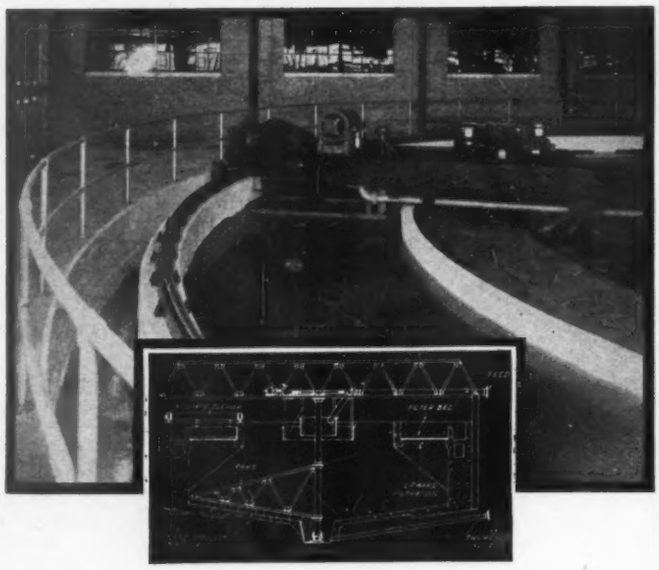

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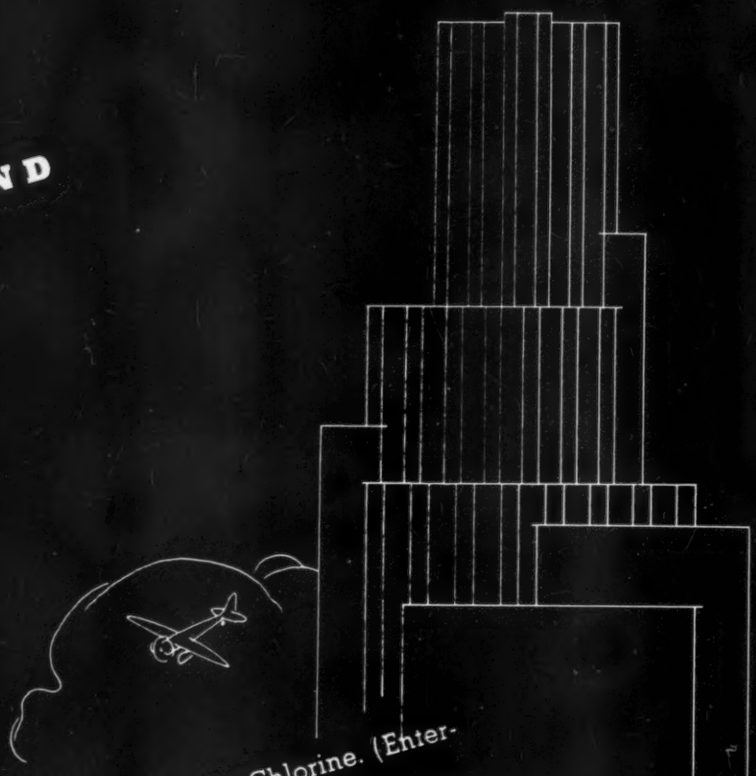

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VOL. 81 NO. 3 MAR. 1934
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EXPERIENCES WITH CHLORINATED-COPPERAS AS A COAGULANT

Economy and Other Benefits Follow Its Use at Dallas, Texas

By L. C. BILLINGS
Superintendent of Filtration, Dallas, Texas

The Author

WHEN considering the comparatively long period during which various methods of water treatment have been in use, it seems a bit startling to conclude that, as a general rule, designers and operators of water purification plants are far from the solution of the problem of properly coagulating water. Flexible designs, patterned to meet the characteristics of the local water to be treated are lacking in many instances. Thus, there is much to be desired; and, many of our organic taste difficulties would be greatly lessened if local designs for mixing clarification and settling were better adapted to making possible greater flexibility in operation. In addition there is need for better coagulation, sought by way of more scientific selections of coagulants.

Coincident with the interest that is gathering momentum in the treatment of sewage with ferric sulphates and chlorides, produced by the oxidation of iron or its bivalent salts with chlorine, bids fair to come a revival of interest of waterworks men in the use of these same chemicals in water treatment. The availability of low priced chlorine makes all this possible and ferrous sulphate oxidized with chlorine holds great promise as an efficient economical newcomer into the field of coagulation.

Dallas, Texas, has used ferrous sulphate and lime as primary coagulants since the beginning of its water purification history. The policy for doing this has been determined from the standpoint of sound reasoning, recognition being given known facts concerning the behavior of various coagulants in handling particular types of surface water.

Nature of Dallas Water

The water delivered to the new Bachman Plant at Dallas is of moderate hardness, average 138 P.P.M., maximum 205 P.P.M., minimum 74 P.P.M. Bicarbonate hardness, average 129 P.P.M., maximum 193 P.P.M., minimum 64 P.P.M. Non-carbonate hardness, average 9 P.P.M., maximum 40 P.P.M., minimum O P.P.M. Magnesium is present to the extent of 5 P.P.M. and under. Color is absent, and turbidities are variable from 50 to 5,000 P.P.M.

Most of the supply is drawn from an artificial lake 30 miles distant. At times of heavy rain the lake supply is supplemented by run off from intervening lands of heavy clay and rich clay-loam. The pH of the water received at the plant is consistently 8.0, making the treatment somewhat difficult with less than 2 g.p.g. of alum. By using lime to moderately soften (4 to 5 g.p.g.), thus raising the pH to 8.6, and with not less than 1 g.p.g. of $FeSO_4$, (copperas) a fair degree of coagulation can be realized. At this pH the precipitation of the hydrates of ferric oxide is sluggish, resulting in uneconomical use of ferrous sulphate. By raising to pH to 9.5 or 10 with lime, the iron sulphate will quickly oxidize and the maximum amount of ferric oxide hydrate will floculate. The

Dallas Filtration Plant with Pumping Station to Left.

resultant caustic condition of the water under such circumstances must be corrected before filtration. This reconditioning can be accomplished by re-carbonation or a heavy secondary coagulation with alum which functions well at this pH. The adjustment with alum is expensive and adds considerably to the non-carbonate hardness.

Experiments indicate that the pH could be depressed to 7 by addition of acid, thus improving conditions for action of coagulants; but due to expense of such treatment and the accompanying increase in permament hardness the process is not appealing.

The Bachman Filtering Plant

The Dallas plant has a total rated capacity of 32 M.G.D. Provision is made for aeration, softening, primary and secondary coagulation, sedimentation and mechanical sand filtration. The plant is equipped for post- and pre-chlorination and ammoniation at will.

The aerator is of the cascade type and the mixing chamber has around-the-end baffles with baffles parallel the length of the rectangular chamber. Velocity in this mixing chamber at 30 M.G.D. rate is 2 ft. per second at beginning and 1.5 ft. per second at end of a 30-minute period. Loss of head through chamber is 19.5 inches.

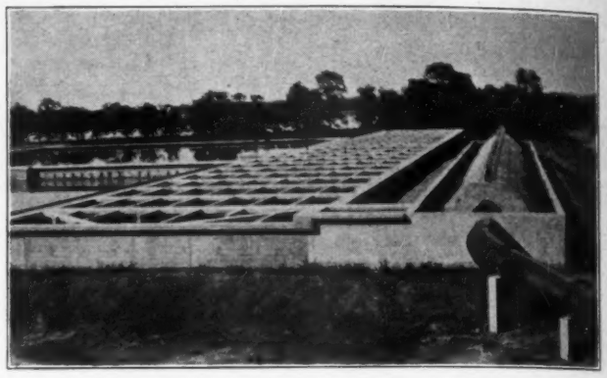
Dry Feed Machines Used for Ferrous Sulphate (Copperas) and Alum, Filtration Plant, Dallas, Tex. (The Chlorine Is Added to the Copperas Solution, Produced by These Machines to Form Chlorinated Copperas During Travel to Point of Application).

The water flow divides at the exit of mixing chamber, part going through a 60-inch sluice gate to a distributing channel along the side of a primary settling basin. The other part of the water is passed through a duplicate arrangement operated in parallel.

On leaving the mixing chamber or primary settling basin the water flows over adjustable weirs and down under false walls. All settling basins are without baffles. A secondary around-the-end baffle mixing chamber is provided for secondary coagulation between secondary settling basin and the filters when needed. The average mixing period here is about 10 minutes.

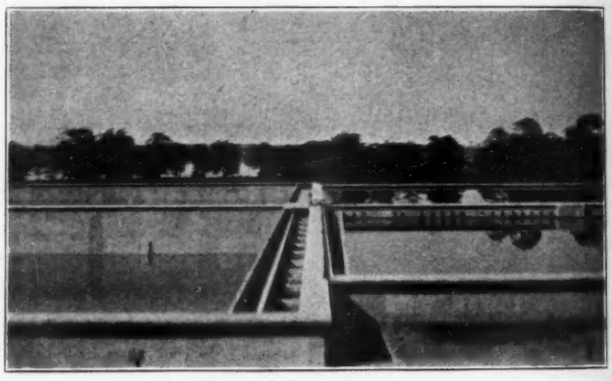
When operating settling basins in parallel-series the basin retention period is 12 hours under average flow conditions. It has been found advantageous to use only one series of basins or one side at a 30 M.G.D. rate and under, thereby reducing the retention period to 6 hours, thus increasing velocity and checking cross current interference in settling.

The filters are of conventional design, sixteen 2-M.G.D. units, each having 720 sq. ft. effective sand area. Strainer



Step Type Aerator and Mixing Chambers, Filtration Plant, Dallas, Tex.

system is of the Pittsburgh type. Filter medium consists of 30 inches of sand and 18 inches of gravel. Sand effective size is 0.45 M.M. and maximum gravel size is 2 in. with the necessary intermediate grades to give a fairly compact gravel layer. Filter equipment consists of hydraulic valves, indicating loss of head and rate of flow gages, and Builders Iron Foundry rate controllers.



Distribution Channels Between Coagulation Basins, Filtration Plant, Dallas, Tex.

Filter washing is by direct pumping, the pumps being in duplicate. Application of wash water is at rate of 8,000 gallons per minute, providing a 16-inch vertical rise per minute through the sand bed.

Quicklime is fed dry and proportioned with a Schaeffer Poidometer which discharges to a slaker. Coagulants are proportioned dry with Municipal Service feeders.

Disinfection is accomplished by post ammoniation and chlorination. Ammonia is applied as a solution of ammonium sulphate with an Omega Precision feeder. Chlorine is fed through Wallace & Tiernan chlorinators from ton containers.

A 5 M.G. underground clear well storage is provided between the filter plant and high service pumping.

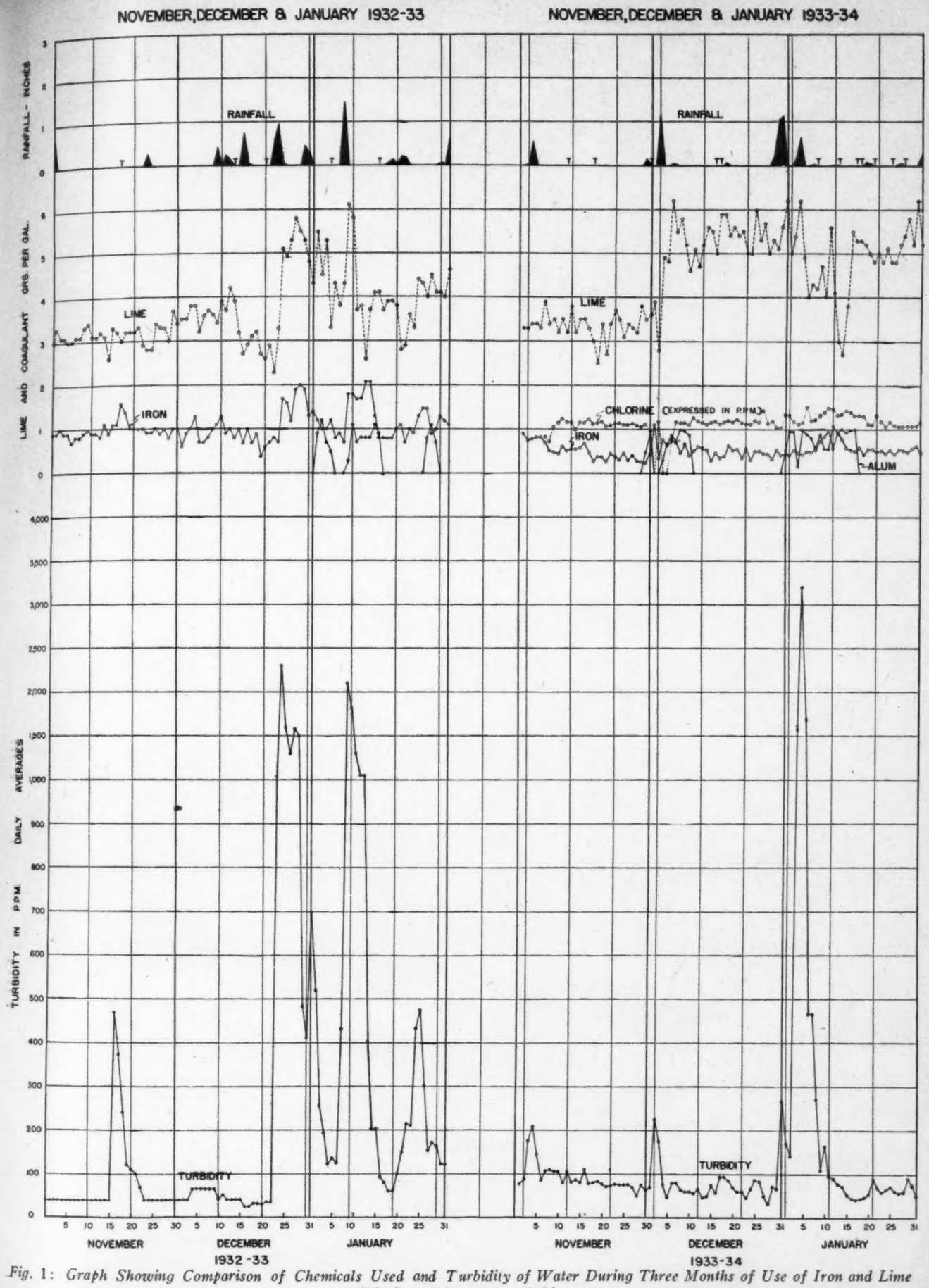


Fig. 1: Graph Showing Comparison of Chemicals Used and Turbidity of Water During Three Months of Use of Iron and Lime vs. Chlorinated Copperas and Lime.

Experiments with Chlorinated Ferrous Sulphate

Early in 1932 comparative laboratory experiments indicated that the O.5 g.p.g. of ferrous sulphate, after chlorination to oxidize the iron, would produce quicker and better floc formation in a water of normal turbidity than would 1 g.p.g. of ferrous sulphate lime to the same amount being added in each case. This inspired a trial in the plant, introducing the chlorine solution into the ferrous sulphate lime at the feeding machine solution box, 200 feet from the point of discharge into mixing chamber. The result was no effective coagulation and damage to lead linings of feeding equipment; and, in a short time a complete stoppage of feed lime.

It was then decided to apply the chlorine solution to the ferrous sulphate solution lime about 15 feet before discharge to mixing chamber. This method was successful and permitted a 10-day trial before the chlorine had drilled a large hole in the iron pipe line opposite the point of its entry. This 10-day trial in April, 1933, with raw water turbidity at 75 P.P.M. and alkalinity at 160 P.P.M. gave an average coagulant cost (ferrous sulphate and chlorine) of $1.04 per 1 M.G. This cost compared with $1.45 per M.G. during a previous 10-day run with lime and ferrous sulphate (no chlorine) where the alkalinity and turbidity had been the same in each instance. The result represented a saving of 41 cents per one M.G.; with better and more effective coagulation in addition.

Plant Scale Results

Beginning November 1, 1933 this method of coagulation was adopted as a regular procedure. Figure 1 gives curves indicating turbidity conditions and chemical application for the period of use of chlorinated-copperas (November and December, 1933, and January, 1934,) compared with the same period in 1932-33 without chlorinated copperas.

Figure 2 depicts the chlorination arrangement in use for the application of chlorine solution to the copperas solution line. The application of the chlorine is made in

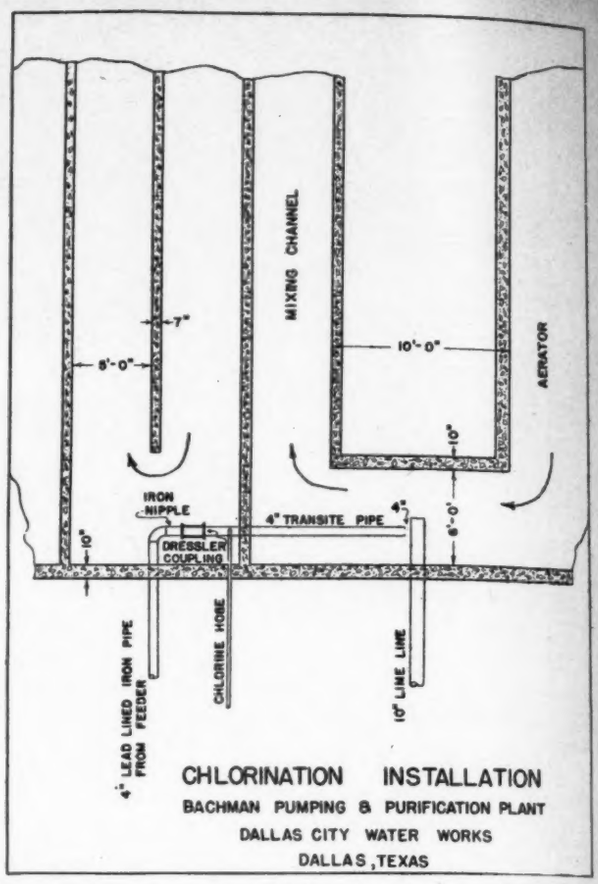


Fig. 2: Arrangement for Chlorinating Solution of Ferrous-Sulphate (Copperas) from Dry Feed Machines and Its Application.

TABLE I

	Chlorine—Copperas and Lime				Copperas and Lime			
	Nov., 1933	Dec., 1933	Jan., 1934	Avg.	Nov., 1932	Dec., 1932	Jan., 1933	Avg.
Turbidity (PPM)—								
Raw Water								
Avg.	92	81	311	161	79	369	420	289
Max.	210	265	3,200	1,225	466	2,266	2,100	1,610
Min.	50	32	44	42	40	25	60	42
Total Alkalinity (PPM)—								
Raw Water								
Avg.	133	143	134	136	138	133	131	1,134
Max.	143	153	157	151	147	152	190	163
Min.	97	127	69	97	131	56	100	95
Total Alkalinity (PPM)—								
Filtered Water								
Avg.	51	33	34	39	62	55	31	49
Max.	67	42	43	50	74	73	45	64
Min.	26	26	26	26	52	29	22	34
Ph. Alkalinity (PPM)—								
Filtered Water								
Avg.	3	9	10	7	4	6	8	6
Max.	6	16	24	15	7	22	21	16
Min.		...	...	...	2	1	2	2
$FeSO_4$								
Avg. lbs. per M.G.	71	73	80	74.6	141	157	173	157.0
Chlorine								
Avg. lbs. per M.G.	8.340	8.757	9.400	8.832	...	...	...	...
CaO								
Avg. lbs. per M.G.	483	756	693	644	453	521	579	518
$FeSO_4$								
@ $1.145 CWT.	$0.813	$0.835	$0.916	$0.854	$1.614	$1.791	$1.980	$1.795
Chlorine								
@ $3.00 CWT.	$0.250	$0.262	$0.282	$0.265	...	...	...	...
Total Primary—Coagulant								
Cost per M.G.	$1.063	$1.097	$1.198	$1.119	$1.614	$1.791	$1.980	$1.795

Avg. saving per M.G.—$0.67.6

TABLE II—COST OF PRODUCING CHLORINATED COPPERAS AT DALLAS, TEXAS

2,000 lbs. Copperas ($FeSO_4:7H_2O$)..$22.90 f. o. b. Dallas
Chlorine required 220 lbs. @ 3 cts. lb... 6.60 f. o. b. Dallas

Total $29.50

Based on available iron content*, the following are equal in cost:

1 ton copperas chlorinated at.....	$ 29.50
1 ton 100% ferric sulphate $Fe_2(SO_4)_3$ at.....	41.00
1 ton 100% ferric chloride ($FeCl_3$) at.....	50.75
1 ton scrap iron and 1.9 tons chlorine =.....	147.50**

To produce 2.9 tons $FeCl_3$**.

For example: Ferric sulphate f. o. b. Dallas would have to be under $41.00 per ton; a ton of scrap iron plus the chlorine required less than $147.50 to compete with chlorine and copperas.

*In iron content, 100 lbs. copperas = 20.1 lbs. Iron, 58.4 lbs. $FeCl_3$, 72.0 lbs. $Fe_2(SO_4)_3$

**Equivalent to 5 tons copperas and 1,100 lbs. chlorine.

the ferrous sulphate lime, which is of special material. A piece of 4-inch "Transite" pipe is connected to the lead lined iron, ferrous sulphate pipe by means of a Dresser coupling and chlorine rubber hose is inserted as far back from discharge end as conditions will permit, which happens to be at 15 feet. When treating flows up to 26 M.G.D. this period of contact has been sufficient for complete oxidation of the copperas to the ferric condition. Inspection of this installation was made after 3 months continuous use and the "Transite" pipe was in perfect condition, showing no signs of deterioration.

Chemical reaction involved in the chlorination of copperas is as follows:

$$3\ FeSO_4 \cdot 7\ H_2O + 1.5\ Cl_2 = Fe_2(SO_4)_3 + FeCl_3 + 21\ H_2O$$

The ferric salts are produced instantaneously and are immediately available for the formation of the ferric oxide hydrate floc resulting from the reaction with bicarbonates, carbonates and hydrates present in water under treatment. One pound of copperas will oxidize to 0.48 lbs. $Fe_2(SO_4)_3$ and 0.19 lbs. $FeCl_3$ requiring 0.11 lbs. of chlorine. The theoretical ratio of chlorine to copperas is 1 to 7.8. In practice, only a slight excess of chlorine is necessary to obtain the desired result. It is good chemistry to have a fairly accurate control of chlorine concentration in chlorine solution and 1 lb. of chlorine to 43 gallons of water seems very satisfactory.

Table I shows a resume of results for 3 months of continuous operation with lime, copperas and chlorine compared with 3 corresponding months of the previous year when lime and copperas were used without the chlorine.

Prepared commercial ferric compounds have been suggested as being more economical coagulants than the chlorinated-copperas, but for Dallas conditions, with heavy freight charges, our calculations indicate that such is not the case locally.

Table II contains, an analysis of the cost of producing chlorinated-copperas vs. that of prepared ferric compounds.

On analysis of results obtained the following advantages of chlorinated copperas are evident:

1. Floc formation clean cut and of proper size.
2. Floc particles tough and resistant to breaking up.
3. Rate of settling is influenced by density of suspended material. Large amount of coarse suspension in raw water or a high bicarbonate alkalinity aids in settling.
4. Floc ordinarily settles well and residual small floc going to filters is distinct and of sufficient volume to load sand beds well without building loss of head unduly.
5. Coagulating effect constant regardless of considerable variation in pH (8 to 9).
6. In handling turbidities around 3,000 P.P.M., 0.5 g.p.g. chlorinated copperas will do the work if pH is elevated above 9.0 with alkalinity showing 5-10 P.P.M. caustic.
7. A saving in coagulant costs results. Over a 3-month period an average saving has been 67.6 cents per M. G. ($10.50 per day) which amounts to a yearly saving of approximately $4,000 at the Dallas plant.

▼

Milwaukee Loses Activated Sludge Case

A court ruling of great importance to many municipalities was handed down March 2 by the U. S. Circuit Court of Appeals at Chicago. This affirmed the decision of the U. S. District Court for the Eastern District of Wisconsin that the city of Milwaukee had infringed the Jones patents for the activated sludge process. A similar suit against the Sanitary District of Chicago is pending and there are also others against Cleveland and Indianapolis.

The patents on the sewage treatment process on which this case was based were obtained in England and the United States by the late Walter Jones, iron founder and justice of the peace of Starbridge, a suburb of Birmingham, but the defendants claimed that Jones obtained the process from Gilbert Fowler, a University of Manchester professor and chemist of the Manchester water works.

The court found that the process was the discovery of Fowler and associate chemists engaged in municipal experiments, but that its successful development was due to Jones, who had had wide experience in sanitation and who employed Fowler.

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Ground-Water Survey in Ohio

A ground-water survey of Ohio is in progress as a project of the Civil Works Administration. This investigation was instituted at the request of the Ohio Water Conservation Board, David C. Warner, executive secretary, and is being directed by the Geological Survey of Ohio. Objects of the survey are:

1. To determine the level of the ground-water table and changes that may have occurred in recent time. (Comparison with surveys made by the United States Department of Agriculture at intervals from 1830 to 1890.)
2. To determine the thickness of the glacial drift and water-bearing horizons therein.
3. To determine the contour of the rock floor, thus outlining the pre-glacial and inter-glacial valleys now deeply buried by drift.
4. To determine the water-bearing horizons in the bed rock.

▼

McNulty Member of Code Authority for Vitrified Clay Sewer Pipe Manufacturing Industry.—Announcement has been made by the National Recovery Administration that Administrator Hugh S. Johnson has appointed Bernard L. McNulty a member, without vote, of the code authority for the Vitrified Clay Sewer Pipe Manufacturing Industry. Mr. McNulty was named as the successor of Ralph Fogg, who has resigned as the Administration member of the code authority, in line with the policy of relieving N. R. A. officials of the responsibilities of participating in code enforcement responsibilities. Mr. Fogg is an Assistant Deputy Administrator of the N. R. A. Mr. McNulty was president of the Marblehead Lime Company of Chicago for eleven years and has been in the lime business since 1912.

OPERATION OF PRÜSS PUMP AT BALTIMORE SEWAGE WORKS

By C. E. KEEFER

Principal Assistant Engineer,
Bureau of Sewers, Baltimore, Md.

THE continued use of the separate sludge digestion process at the Baltimore sewage works has made it desirable during the past eight or ten years to carry on extensive experiments both in the laboratory and the field in order to learn as much as possible about the process. As part of these investigations a Prüss circulating pump was purchased at a cost of $1,080, and installed in one of the existing digestion tanks at the sewage works. The operation of the pump and its effect on sludge digestion was observed over a period of a year, during which time another tank of a similar design but without a pump was kept in operation. At the end of the test period it was concluded that the tank with the pump produced 21 per cent more gas than the other digestion unit. In the latter tank, however, there was considerably more liquefaction of solids. As far as could be determined, the operation of the pump did not hasten the digestion process.

Experience with Pruss Pumping Equipment in Germany

The desirability of mixing ripe sludge with raw material in order to seed the undigested solids and thus promote digestion was recognized many years ago. Numerous devices have been used in order to mix sewage sludge. One of these, which has been used to a considerable extent within the past few years in the Essen District, Germany, is the Prüss pump, named after its inventor.

In 1925 Blunk and Prüss[1] were granted a German patent, which covered circulating sewage sludge from the bottom to the top of a digestion tank. The equipment used for this purpose (see Fig. 2) consisted of a vertical

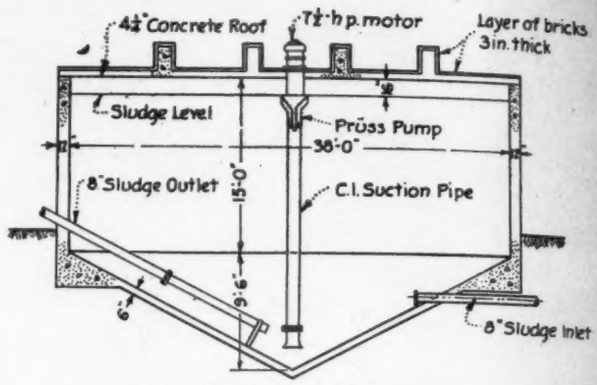

Fig. 2—Section of Sludge Tank 12

pipe suspended in the center of the digestion tank. The bottom or suction end of the pipe, which was open, terminated just above the tank bottom. In the top of the pipe and at the surface of the sludge was an impeller, somewhat similar to that used in a screw pump. This impeller was direct connected by means of a shaft to a vertical motor on the digestion tank roof. The discharge from the impeller was radially outward so that the ripe sludge drawn from the bottom of the tank was distributed over the tank surface, and gradually settled again to the bottom. Provision was also made so that by running the pump backwards the scum at the top of the tank could be discharged at the bottom. Some of the first installations were at Essen-Frohnhausen, Essen-Nord and Gelsenkirchen.

The purpose of pumping the gas filled sludge at the bottom of a tank to the surface is to permit the release of gases. Prüss[2,3,4] points out that the solubility of

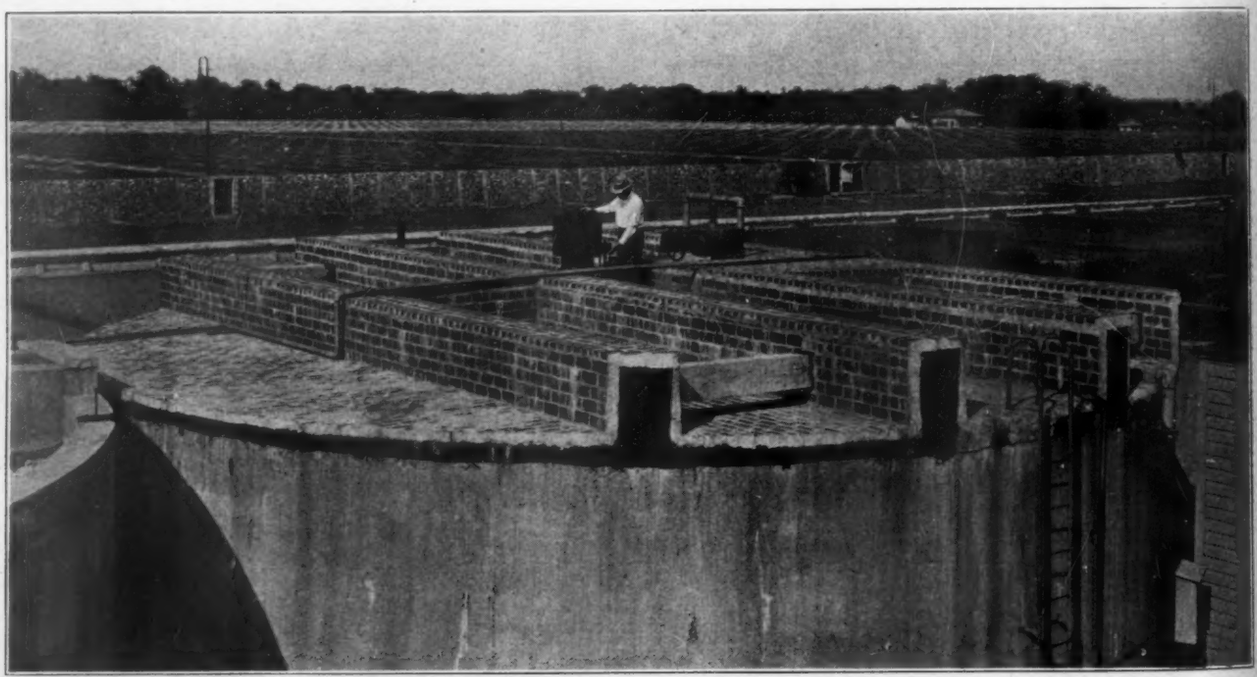

Fig. 1—Sludge Tank 12, Equipped with Prüss Pump, Baltimore Sewage Treatment Works. (Tank on Left Is the Control Tank With No Stirring.)

carbon dioxide in a tank 32.8 ft. deep is twice that at the tank surface. He claims that at this increased pressure the bacteria absorb considerably more carbon dioxide than at normal pressures, and as a result bacterial activity is inhibited. The release of this gas, therefore, is desirable. He also states that as methane is only slightly soluble in water, the bacteria become surrounded with an envelope of methane gas, and are separated from the sludge particles.

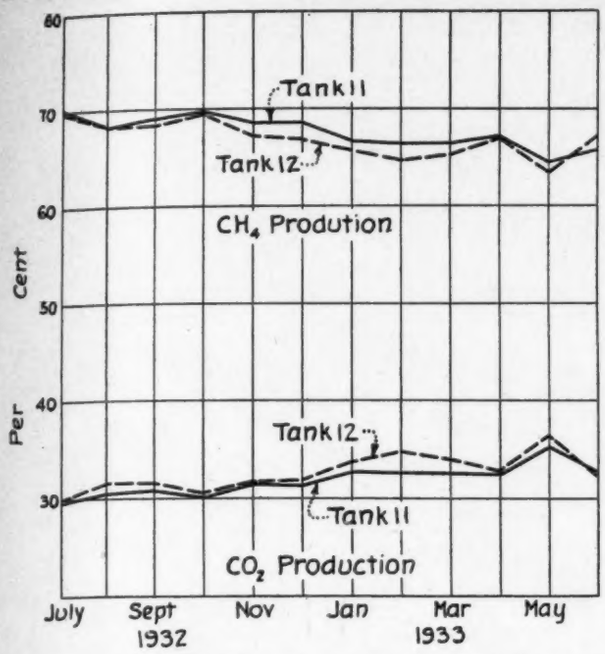

Fig. 3—CH_4 and CO_2 in Gases Produced by Sludge Tanks 11 and 12

He recommends circulating the tank contents two hours daily by pumping sludge to the top of the tank for one hour and scum to the bottom for the other hour. By following this practice the quantity of gas developed is said to be doubled, and twice as much material can be digested as in a tank with no stirring equipment. Furthermore, difficulties with scum are practically eliminated, because it is pumped to the bottom of the tank. Prüss[5] states, furthermore, that when fresh solids are mixed with ripe sludge, the digested material begins again to produce additional gas, which would not have been generated if the fresh solids had not been added.

Fries[6] gives data on experiments conducted at the Essen-Rellinghausen sewage works in order to see if the circulating of sludge in the Imhoff tanks would help to relieve the overloaded condition. The investigation lasted from April 13 to May 10, 1928. The sludge was circulated by means of a diaphragm pump from the bottom to the top of the tank. Approximately 28,300 cu. ft. of gas were produced when the sludge was circulated and 24,700 cu. ft. when the sludge was quiesent. The increase due to pumping was 14.6 per cent. The moisture in the uncirculated material varied from 82 to 90 per cent, and the moisture in the circulated sludge was about 95 per cent. The carbon dioxide in the gas generated by the pumped sludge averaged 25 per cent with concentrations as high as 36 per cent. On the whole better results were obtained when the sludge was not circulated.

Relative to these unsatisfactory results Prüss[7] and Blunk point out that the sludge at the Essen-Rellinghausen sewage works was handled by means of a membrane pump. In their opinion a pump of this design could not be gas tight, and therefore considerable gas must have escaped. They also state that the test lasted for four weeks only, a period much too short to reach any definite conclusions.

One of Sierp's[8] objections to the stirring of sludge in digestion tanks is that the zone of insulating material, which lies next to the tank walls, is destroyed and the "cold sludge is then mixed with the remaining sludge, thus artificially lowering the temperature of the total volume of sludge." He also states that "intensive mixing of the total contents of a tank prevents the necessary stratification of sludge according to its age and degree of digestion. It could easily happen, if the contents are mixed, that fresh, undigested sludge would be withdrawn from the bottom of the tank, while the digested sludge would remain in the tank, probably in the upper part."

Prüss[9,10] answers Sierp's criticisms by stating that during five years of experience with the dewatering of ripe sludge there has never been any difficulty to speak of in drying the material. Prüss admits that, theoretically speaking, the sludge withdrawn would contain some raw solids, but the amount would be so small that the drying would not be more difficult. In fact the "ripe sludge contained less organic matter than the ripe sludge from a tank" where the sludge was not stirred. In a later discussion Sierp[11] concludes that sludge circulation increases the gas yield from 10 to 20 per cent, that the additional volume of gas is mostly carbon dioxide, and that there is no proof "that a sludge tank, equipped with means for circulating the sludge, can be made smaller than usual."

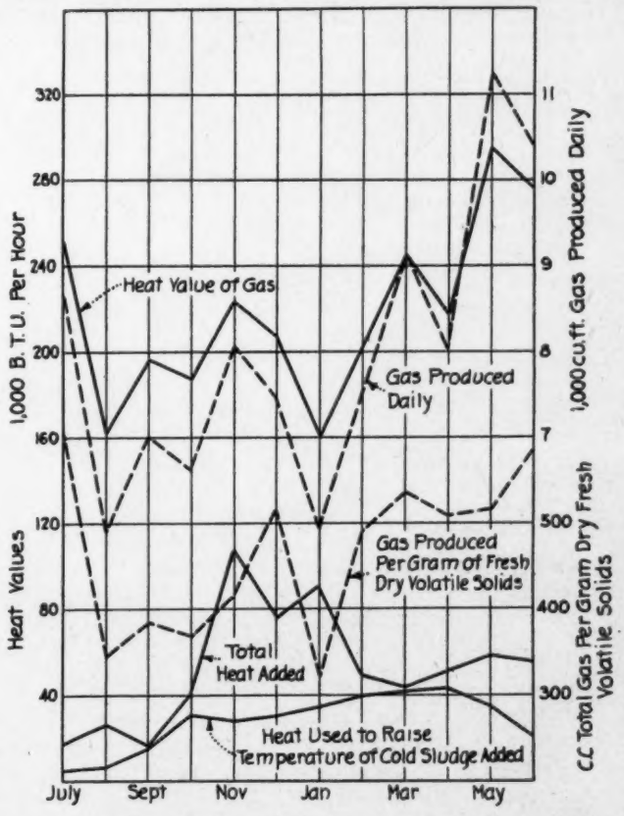

Fig. 4—Heat Added and Gas Production Sludge Tank 11

Husmann[12] reports on the operation of the Prüss pumps at the Essen-Frohnhausen sewage works. He points out that within a few hours after the circulation of sludge has been stopped, the solids begin to separate from the supernatant liquor. Two hours after the pumping of sludge had ceased, he found the sludge to contain 88.0 per cent moisture at a distance of 15 ft. below the tank surface, and even less moisture at greater depths.

The upper 15 ft. consisted of sludge liquor with a water content varying from 99.34 to 99.65 per cent. Husmann also indicates that the carbon dioxide content of the gas was 30.65 per cent while the sludge was being pumped and 30.35 per cent after circulation has ceased. The difference between these two groups of results is very small.

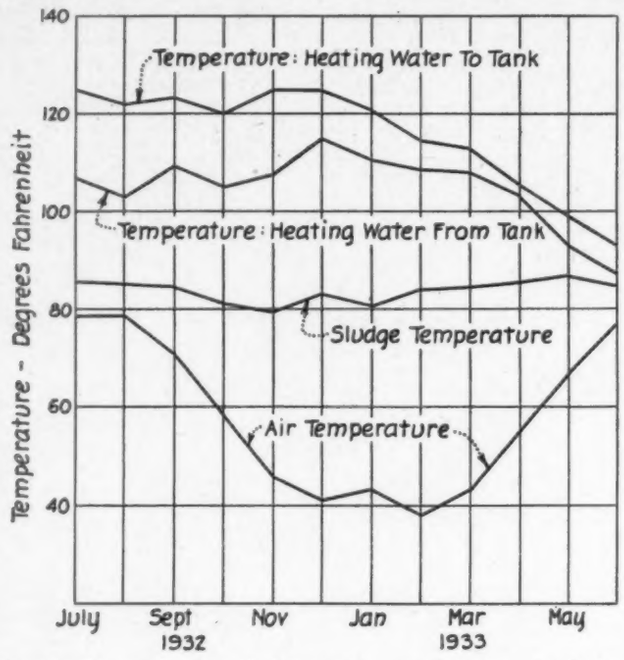

Fig. 5—Temperature of Heating Water, Sludge and Air, Sludge Tank 11

Pruss Installation in Baltimore

A study of the literature dealing with the use of Prüss sludge circulating pumps indicates that there are little published data on the operation of this equipment. As conditions at Baltimore are especially suitable for studying the operation of a Prüss pump, one of the existing sludge tanks was provided with one of these units. The operation of this tank was then compared with one of almost identical design, which, however, did not contain a pump.

Both of the tanks (see Fig. 1), which are built of concrete, are 38 ft. in diameter with walls 12 in. thick. The tanks have a depth of 15 ft. at the side walls and 24 ft. 6 in. at the center with cone-shaped bottoms 6 in. thick. Raw sludge enters the tank through an 8-in. pipe a few feet below the top, and digested sludge is withdrawn from the bottom through an 8-in. pipe. The tanks project 12 ft. above the ground with the walls exposed. The unit without the Prüss pump has been called Tank 11, and the one with the pump Tank 12.

Tank 11, which has been in continuous service since Aug. 1, 1930,[13] is provided with a reinforced concrete roof 4½ in. thick, supported by heavy concrete beams. The tank contains 20,600 cu. ft. of sludge when filled with the under side of the roof submerged. Means are provided for withdrawing supernatant liquor through a 4-in. pipe from two points, one 6.3 ft. and the other 11.8 ft. below the roof. Five, standard, 2-in. genuine wrought iron continuous pipe coils were hung around the inside of the tank walls for heating purposes. This piping, which is galvanized, has a radiating surface of 381.7 sq. ft., and is 0.154 in. thick.

Tank 12 (see Figs. 1 and 2) is similar to Tank 11 with the following exceptions. The roof is of reinforced concrete, 4½ in. thick, and is covered with five-ply, asphalt felt roofing material to prevent the escape of gas through the concrete. A layer of bricks, 3 in. thick, set in cement mortar, is provided on top of this gas-proofing membrane. The bricks provide sufficient weight so that the felt roofing would be held in place in case gas gets between the concrete deck and the roofing. The Prüss pumping mechanism is driven by a 7½-hp. motor, which operates at 900 rev. per min. The mechanism is suspended from the concrete roof and the bottom of the suction pipe, which is 300 mm. (11.81 inches) in diameter, is 24 in. above the tank bottom. The impeller at the top of this pipe is set so that the material pumped is discharged at the surface of the sludge. The top of the sludge or scum is 16 in. below the under side of the roof. The capacity of the tank up to this level is 19,090 cu. ft., i.e., 1,510 cu. ft. less than Tank 11. The tank is provided with four 2-in. galvanized, genuine wrought iron pipe coils with a heating surface of 286 sq. ft. The pipe, which have a wall thickness of 0.154 in., are suspended around the inner face of the tank walls. Pipes, 4 in. in diameter, are

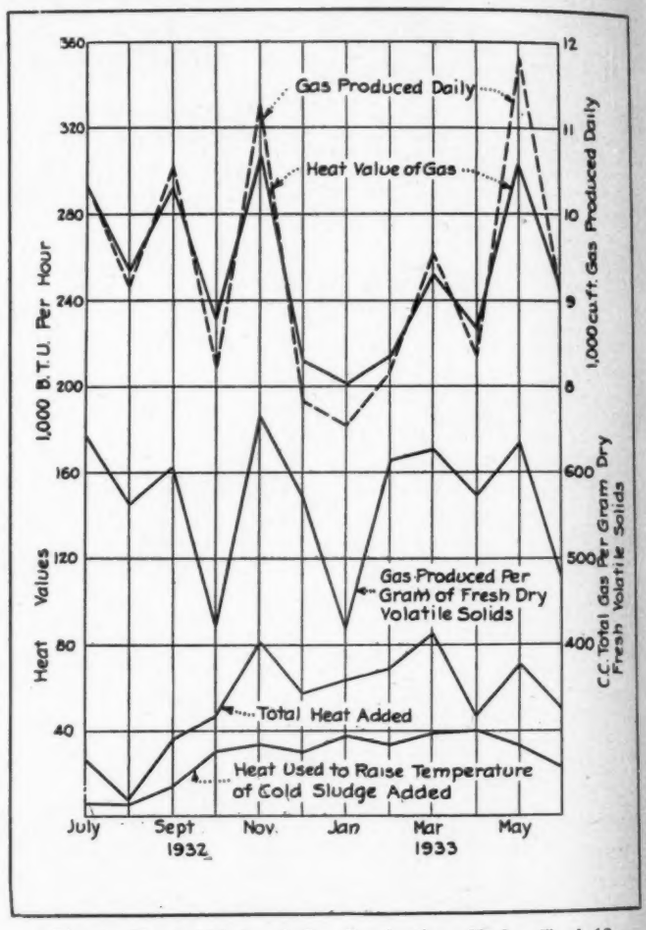

Fig. 6—Heat Added and Gas Production, Sludge Tank 12

provided for draining sludge liquor from the tank at points 5.68 ft. and 10.43 ft. below the roof.

The auxiliary equipment used in conjunction with the operation of the digestion tanks consists of two gas boilers, one with a rating of 212,500 and the other 420,000 B.t.u. per hr. These boilers supply steam to two hot-water heaters. Hot water is circulated through these heaters to the pipe coils in the tanks by means of a motor-driven centrifugal pump. This water is measured by means of hot water meters, and the temperature of the water together with that of the sludge in the tanks is obtained by recording thermometers, which are calibrated at regular intervals. Tank 11 is equipped with two recording thermometers, one 5½ ft. and the other 17 ft.

below the roof on a vertical line approximately 6 ft. from the vertical axis of the tank. Tank 12 has one recording thermometer, which is 6.8 ft. below the roof, and 6 ft. inside the inner face of the tank wall. The gas generated by the tanks is measured by means of

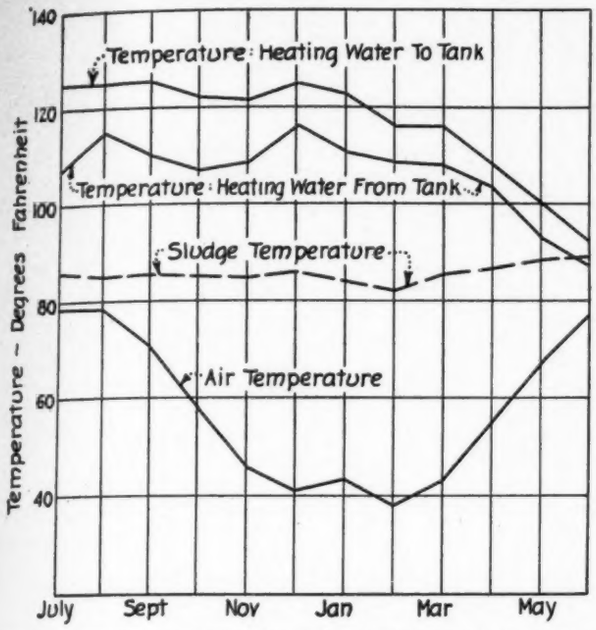

Fig. 7—Temperature of Heating Water, Sludge and Air, Sludge Tank 12

Connersville rotary gas meters, and that used by the boilers is determined by a meter made by the Maryland Meter Works. The excess gas is stored in a gasometer with a capacity of 15,100 cu. ft.

Operation of Tanks

The period, during which the two tanks were operated under conditions as nearly identical as possible, began on July 1, 1932, and terminated one year later on June 30, 1933. As previously stated, Tank 11 had been in service for 23 months prior to the beginning of these studies. Although Tank 12 was put in operation on June 1, 1932, the results obtained during June, 1932, are not given, as it was considered desirable to operate the tank for one month so that normal conditions would exist.

The raw sludge digested in these tanks was pumped from the preliminary settling basins at the sewage works. The material was added once a week, usually on Monday. More rapid digestion of the solids would undoubtedly have resulted if daily additions had been made, but to do so would have seriously interfered with the routine operation of the sewage works. The operating procedure consisted of withdrawing the required quantity of digested sludge, or preferably supernatant liquor, if there was any present. The tanks were then immediately thereafter filled with raw sludge. Samples were obtained in order to determine the pH value, temperature, volatile matter and moisture. As indicated by Tables I and II, the sludge added to Tank 11 contained, on the average, 72.3 per cent volatile matter with 95.0 per cent moisture, and the material pumped into Tank 12 had an average of 73.8 per cent volatile solids and 94.8 per cent moisture. The quantities of material added weekly to the two tanks is given in Table III. It should be noted that somewhat more sludge was put into Tank 11 than into Tank 12, as the former has a slightly larger capacity.

The materials drawn from the tanks have been segregated into two groups: digested sludge and supernatant liquor. All materials with a solids content greater than

TABLE I—RESULTS FROM TANK 11 WITHOUT STIRRING EQUIPMENT

	Wet Sludge				Dry
	Quantity Cu. Ft.	Moisture %	Volatile Matter %	Dry Solids Cu. Ft.	Volatile Solids Cu. Ft.
Raw sludge added...	167,694	95.0	72.3	8,451	6,163
Digested sludge withdrawn	44,634	94.1	55.2	2,645	1,460
Supernatant liquor withdrawn	123,060	99.6	...	492	....
Estimated number of persons served			12,530		
Estimated tank capacity per person			1.64 cu. ft.		
Gas Production:					
Total for year			2,852,400 cu. ft.		
Daily average			7,815 cu. ft.		
Daily average per capita served.			0.62 cu. ft.		
Per lb. of fresh volatile solids..			7.30 cu. ft.		
Heat transfer through pipe coils...			9.29 B. t. u./hr./°F./sq. ft. of pipe surface		

TABLE II—RESULTS FROM TANK 12 WITH PRÜSS STIRRING EQUIPMENT

	Wet Sludge				Dry
	Quantity Cu. Ft.	Moisture %	Volatile Matter %	Dry Solids Cu. Ft.	Volatile Solids Cu. Ft.
Raw sludge added..	158,948	94.8	73.8	8,198	6,054
Digested sludge withdrawn	101,296	96.4	54.9	3,667	2,013
Supernatant liquor withdrawn	57,562	99.6	...	262	....
Estimated number of persons served			12,150		
Estimated tank capacity per person			1.57 cu. ft.		
Gas Production:					
Total for year			3,352,600 cu. ft.		
Daily average			9,185 cu. ft.		
Daily average per capita served.			0.75 cu. ft.		
Per lb. of fresh volatile solids..			8.70 cu. ft.		
Heat transfer through heating coils			9.73 B. t. u./hr./°F./sq. ft. of pipe surface		

TABLE III—QUANTITIES OF RAW SLUDGE ADDED WEEKLY TO TANKS

Date	Tank 11 Cu.Ft.	Tank 12 Cu. Ft.
July 1, 1932, to Feb. 26, 1933.....	2,884[1]	2,673[1]
Feb. 27, 1933, to June 30, 1933.....	3,605[2]	3,340[2]

[1]Quantities are equivalent to daily additions, amounting to 2% of the tank volumes.

[2]Quantities are equivalent to daily additions, amounting to 2½% of the tank volumes.

2 per cent have been called sludge, and withdrawal with a lower solid content have been classified as supernatant liquor. A total of 44,634 cu. ft. of digested sludge containing 94.1 per cent moisture was removed from Tank 11, and 101,296 cu. ft. with a moisture of 96.4 per cent were drawn from the stirred tank—Tank 12. On the other hand 123,060 cu. ft. of supernatant liquor were removed from Tank 11 and 57,562 cu. ft. from Tank 12.

The significance of the above-mentioned figures is apparent. There was considerably greater liquefaction of solids in Tank 11, where the material was in a quiescent condition. A total of 114 per cent more sludge liquor and 56 per cent less sludge was drawn from Tank 11 than from Tank 12. The sludge removed from Tank 11 was in a much more concentrated condition, containing 64 per cent more solids, than that taken from Tank 12. It would seem that a sewage works, provided with sludge tanks containing Prüss equipment, would have to have considerably more sludge drying facilities than a plant where such equipment was not used. On the other hand, there would be more supernatant liquor to dispose of at the latter type of plant, but where this liquor is added either to the raw or the treated sewage, it should not increase the flow more than 0.2 to 0.3 per cent.

The character of the ripe sludge withdrawn from the two tanks, when judged on the basis of volatile solids content, was practically the same. The material removed

from Tank 11 contained 55.2 per cent volatile solids, and that from Tank 12 had 54.9 per cent. These results indicate that the tanks digested the solids to about the same extent. Apparently there should be little occasion for apprehension that any perceptible quantity of raw sludge would be withdrawn along with the ripe material from a tank with Prüss equipment.

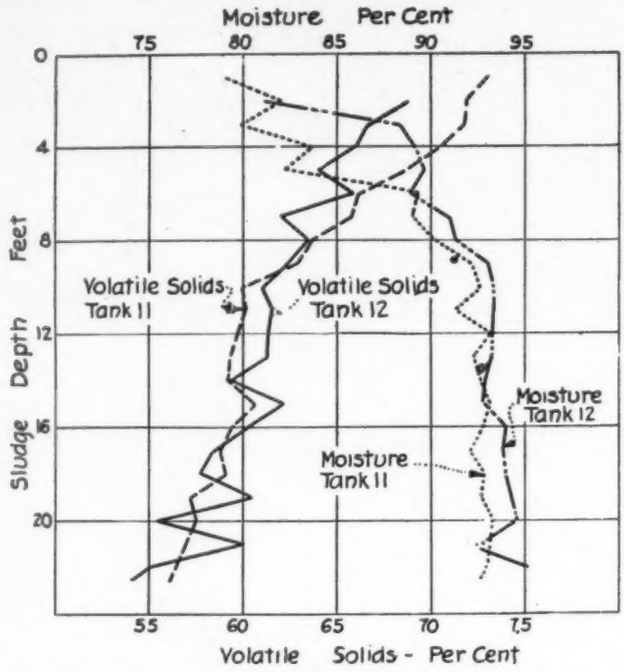

Fig. 8—Moisture and Volatile Solids of Sludge in Tanks 11 and 12

The gas produced by the tanks is of particular interest. During the 12-month period 2,852,400 cu. ft. were generated by Tank 11 and 3,352,600 cu. ft. by Tank 12. As Tank 11 contained 7.9 per cent more sludge than Tank 12, the best way to compare the gas productions is on a per capita basis. Tank 11 yielded 0.62 cu. ft. of gas per capita per day, and Tank 12 produced 0.75 cu. ft.—an excess of 21 per cent. It is reasonable to assume that the circulation of the sludge increased the volume of gas generated, but this increase was far from the 100 per cent reported by Prüss. Contrary to Sierp,[11] however, there was nothing to indicate that this greater production of gas was due to a larger percentage of carbon dioxide being present. Analyses of the gas, which were made weekly, are given in Fig. 3. Throughout the 12-month period there was an average of 32.6 per cent carbon dioxide in the gas generated from Tank 12 and 31.8 per cent from Tank 11, an increase of 2.5 per cent only. This difference was most likely due to the release of dissolved carbon dioxide, when sludge near the bottom of the tank, was pumped up to the top.

Figure 4 gives the heat value and quantity of gas produced together with the heat introduced into Tank 11 during each month of operation. The total quantity of heat added varied from a minimum of 16,620 to a maximum of 108,060 B.t.u. per hr. with an average of 52,850 B.t.u. The temperature of the raw sludge pumped into the tank varied from 48° F. in March to 80° F. in August. As indicated by Fig. 5 the temperature of the sludge in the tank was kept between 79.5° and 86.8° F., with an average temperature of 83.7° F. The heat added to increase the temperature of the raw sludge varied from 4,944 to 41,886 B.t.u. per hr. with an average of 27,130 B.t.u. The average quantity of heat lost due to conduction was 25,720 B.t.u. per hr. It was of particular interest to know the conduction losses during the winter months. For the five-month period from Nov. 1, 1932, to March 31, 1933, these losses averaged 38,850 B.t.u. per hr. The gas production varied from a minimum of 5,910 cu. ft. per day in January to a maximum of 11,268 cu. ft. in May. The pipe coils in the tank transmitted 9.29 B.t.u. per hour per square foot of heating surface per degree temperature difference.

The heat added to Tank 12 and the gas generated during the investigation are shown in Fig. 6. The heat required to raise the temperature of the incoming cold sludge averaged 27,591 B.t.u. per hr. The heat lost due to conduction averaged 25,613 B.t.u. per hr., or 107 B.t.u. per hr. less than the conduction losses from the unstirred tank—Tank 11. The conduction losses from Nov. 1, 1932, to March 31, 1933, averaged 35,760 B.t.u. per hr. as compared with 38,850 B.t.u. per hr. from Tank 11. These results are not in accord with the conclusions reached by Sierp,[8] and Rudolfs[14] and Miles that the stirring of sludge tends to increase the heat losses. The quantity of gas evolved ranged from a minimum of 7,523 cu. ft. per day in January to a maximum of 11,839 cu. ft. in May. Figure 7 shows the temperatures of the air, the sludge and the water used to heat the tank. The average temperature of the sludge in the tank for the 12-month period was 85.7° F., or 2° higher than the sludge in Tank 11. On several occasions temperatures of the sludges in the two tanks were obtained from the top to the bottom of the tanks at one-foot intervals. Below the scum these temperatures were generally quite uniform, and correspond closely to the temperatures given by the recording thermometers. The heat transfer through the pipe coils in Tank 12 averaged 9.73 B.t.u. per hour per square foot of heating surface per degree temperature difference.

Once a month samples of sludge were collected from the top to the bottom of the tank at one-foot intervals, and the moisture and volatile solids were determined. The results obtained at each sampling point were averaged through the year, and are shown in Fig. 8. It was expected that the moisture of the sludge in Tank 12, especially in the middle and the lower portions, would be

Fig. 9—Obstruction Removed from Prüss Pump, Sludge Tank 12, Baltimore Sewage Treatment Works

considerably higher than in Tank 11. Such, however, was not the case. The scum in Tank 11 was usually about 5 ft. thick with a moisture well below 84 per cent. On the other hand the scum in Tank 12 was only about a foot thick. Below this 5-ft. scum layer in Tank 11 the moisture usually varied from about 89.0 to 93.3 per cent with the denser sludge near the scum. The average moisture throughout the whole tank for the 12-month period was 88.9 per cent. Beneath the scum in Tank 12 the moisture varied from 88.3 to 95.2 per cent with the denser materials near the top. The average moisture of the sludge in the tank was 91.4 per cent.

The volatile solids at various elevations in the tanks are also shown in Fig. 8. The upper 9 ft. of sludge in Tank 11 contained more volatile solids than the material in Tank 12. Below this elevation, however, the sludges in the two tanks had about the same volatile solid content. The average volatile material of the sludge was 63.8 per cent in Tank 11 and 62.5 per cent in Tank 12. As judged by the volatile solids it is reasonable to assume that the speed of digestion was at about the same rate in both tanks.

Difficulties Encountered

As a general rule no difficulty was had with the operation of the Prüss pump. On Oct. 24, 1932, however, nearly five months after the tank was put in service, a violent vibration was observed when the drive motor was started. The tank was taken out of service, and the pump was inspected. It was found that one of the castings enclosing the pump shaft immediately above the impeller had become broken. This breakdown was caused by a rope-like obstruction (see Fig. 9), which had gradually formed over a period of months in the impeller of the pump. This obstruction consisted of short pieces of string, match sticks, hair, clothes-pins and other similar materials, which had gradually become woven into a long heavy coil of sufficient strength that it could be pulled apart only with great difficulty. In view of this experience it would seem preferable to have the pumping equipment accessible for cleaning and repairs by having it outside the tank.

Summary

The following is a summary of the results obtained when using Prüss equipment in a digestion tank as contrasted with a tank, in which the sludge was not circulated.

1. Sludge digestion was not accelerated.
2. The solid content in the ripe sludge withdrawn was much less.
3. The liquefaction of solids was one-half as great.
4. Considerably more digested sludge and correspondingly less supernatant liquor was withdrawn.
5. The solid content in the sludge throughout the main portion of the tank was less. Although the difference was not great, it was sufficient to create quite a difference in volume of sludge drawn.
6. There was less scum formation.
7. The heat losses from the tank were no greater.
8. There was no increase in the percentage of volatile solids in the ripe sludge withdrawn.
9. There was only a slight increase in the content of carbon dioxide in the gas.
10. The total gas production was increased 21 per cent.

The sewage works is under the general supervision of B. L. Crozier, chief engineer, Department of Public Works, and George E. Finck, sewerage engineer, with G. K. Armeling, superintendent. Acknowledgments are due to Edw. Cromwell, principal sanitary chemist, Paul Smith, Harry Weiner and J. W. Bushman, junior chemists, who assisted in the laboratory and field work.

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Novel Sludge Drying Scheme Installed at Plainfield, N. J.

Spray-drying of emulsions and suspensions is not new in industrial processes such as the production of milk-powder, soap-powder and the like. The scheme when applied to sewage-sludge, however, is decidedly new and the first installation at a sewage treatment works is now ready to start operation at the Joint Disposal Works of Plainfield, and Dunellen, N. J. By the time this issue goes to press the new plant, according to John R. Downes, Superintendent of the Plainfield plant, should be in actual operation.

The spray-drier consists of a circular chamber, twenty feet in diameter and about the same height. A centrifugal spraying machine, suspended from the center of the roof, atomizes the sludge and throws the resulting spray horizontally into the chamber. Hot air is admitted and distributed just below the spray table and is sucked downward and out through ports around the periphery of the chamber and just above the floor. The drying takes place as the sludge spray descends through the hot air and the pulverant material produced is collected by a revolving scraper delivering to a center schute through the floor. The moisture in the dried sludge is to be maintained at the most economical point which will just interfere with the ease of handling. The air is to be heated by a coal burning furnace, equipped to burn the powdered sludge whenever desired. If such disposal proves more economical than marketing it as fertilizer—which is not probable in the Plainfield district—sludge will be burned continuously. Temperature control is designed to preclude sludge scorching and odor nuisance.

The equipment used in the drying plant was developed by Industrial Associates, Inc., of New York City, and represents an adaptation of their industrial equipment to meet requirements in sewage sludge drying.

In a subsequent issue of WATER WORKS AND SEWERAGE there will appear an article by John R. Downes, Superintendent of the Plainfield plant, which will adequately describe the new plant and its operation.

A SELF-LIQUIDATING WATER PLANT IMPROVEMENT

By CHARLES P. HOOVER*

C. P. Hoover

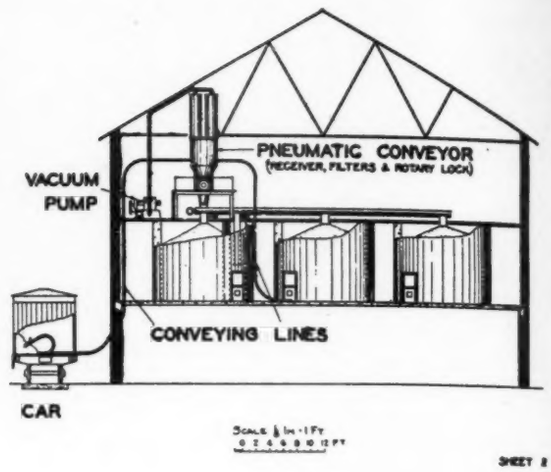
SODA-ASH, used in softening the city water at the Columbus plant, was purchased in 200 lb. burlap bags from 1908 until 1931. Cars were unloaded by hand, and the bagged ash was stored on the lower floor. A bag conveyor (see photograph) was used to transport the bags, as needed, to the feeding floor, where the ash was fed manually into the dissolving tanks from which it discharged into concrete chemical solution tanks which have been converted into storage bins shown in the accompanying sketches. In 1931 it became possible to make a saving of 50 cents a ton by purchasing soda-ash in 100 lb. paper bags, and for two years advantage was taken of this economy.

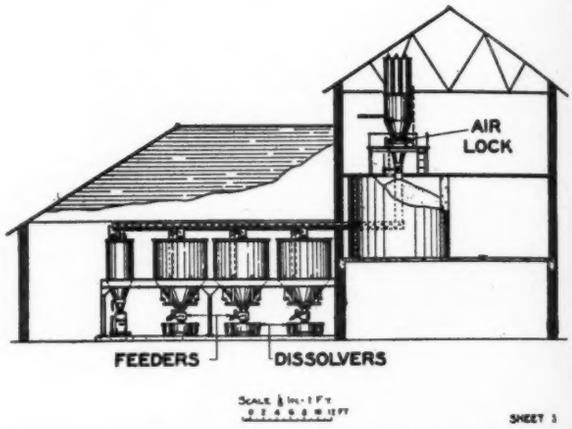
It was possible to obtain a further and appreciable saving of $2.50 per ton by purchasing soda-ash in bulk, and for some time methods were considered for unloading the material in this form, storing, weighing and delivering it to the dissolvers. In 1925 the pneumatic suction system of chemical handling was first installed in a municipal filtration plant, and during the succeeding years the advantages of the system have brought it into use in almost every new plant using soda-ash, alum, or lime, in any reasonable quantity.

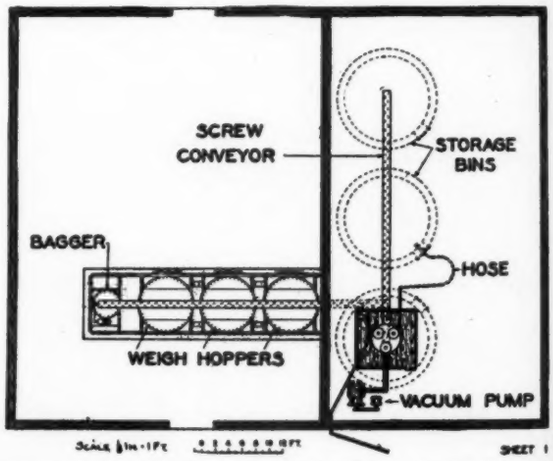
The building at Columbus had not been designed for penumatic handling equipment, so the problem was quite different from that of incorporating pneumatic conveying and bulk storage facilities in new plants at the time of designing them. It was found, however, that the cylindrical concrete soda solution tanks could be converted to bulk storage bins for dry soda-ash with very few changes. There was sufficient space above these

*Chemist in Charge Water Softening and Purification Works, Columbus, O.

Old Apron Conveyor Used for Elevating Soda-Ash at Columbus. Compare This With the Modern Equipment, Shown in Accompanying Illustrations, Which Has Replaced It.



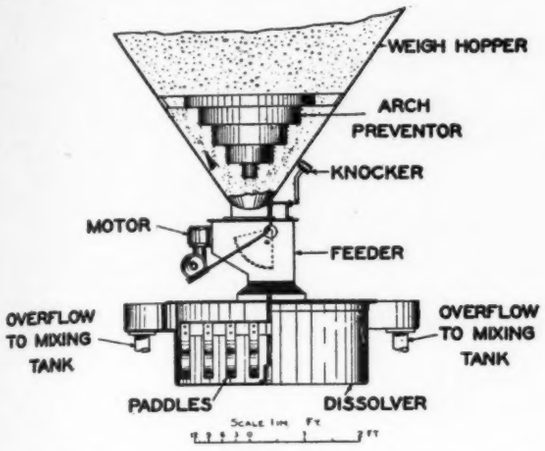




Pneumatic Chemical Unloading, Storage and Feeding Equipment, Columbus, O., Water Softening Plant

bins for a penumatic receiving station, from which the ash could be conveyed to any of the three bins, or to the weigh hoppers, by a screw conveyor. The portion of the building formerly used for bag storage was ample for the installation of weigh hoppers and dissolvers, and the final arrangement of the new equipment is indicated in the sketches.

The pneumatic unloading system consists of the intake pipeline, including flexible hose and an intake nozzle,



Chemical Feeder, Columbus, O., Water Softening Plant

receiving station, filters to clean the conveying air, and a vacuum pump. To unload a car of soda-ash, the vacuum pump and the motor to drive the discharge mechanism under the receiving station are started. Atmostpheric air is drawn in at the intake nozzle, and when the nozzle is immersed in the material, the inflow of air picks up the soda-ash and conveys it in a steady stream at high velocity to the receiving station. There the abrupt decrease in velocity causes the precipitation of the material in the hopper, while the conveying air is drawn up through the filters, which consist of three cylindrical housings containing cloth tubes. The air passes up through the tubes, but the cloth retains the fine dust particles, so that only cleaned air is drawn through the pump and discharged to the atmosphere. There is an automatic arrangement to clean the dust regularly from the cloth tubes in each filter compartment, so operated that the dust feeds out of the system continuously with the coarser particles.

The soda-ash, which is discharged through the rotary air lock, may be taken by screw conveyor to either of the three storage bins, or directly to process. Each of the three weigh hoppers hold 5 tons of ash, so 15 tons of each carload can be taken directly to these hoppers, while the balance can be held in the car until time for demurrage to start on the car or it can go to the storage bins. To take the ash from storage to the weigh hoppers, a second intake pipeline is used. The hose and nozzle are attached to a "reclaiming" line, and the nozzle can be inserted in any bin through an access door. The three concrete storage bins do not hold a sufficient reserve of soda-ash to meet all requirements, so a bagger is installed beside the weigh hoppers. As much material as may be required can be unloaded from a car, bagged, and stored in the same manner as was followed before the installation of the pneumatic system.

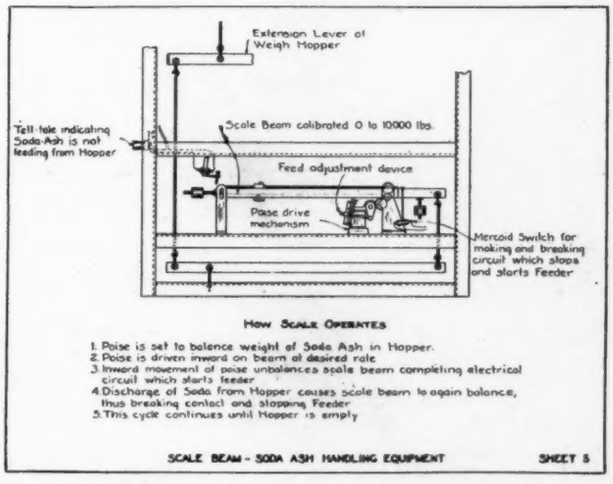
Chemical Feeder

A motor driven feeder is bolted to the bottom of each weigh hopper and both hopper and feeder are supported by weigh levers. The weigh levers are connected to a weigh beam which is calibrated from 0 to 10,000 lbs. in 2 lb. graduations. When the hopper is filled with soda-ash, the poise on the weigh beam is moved manually to the point where it indicates the weight of the material in the hopper. When the machine is put into operation the poise is mechanically driven inward on the beam at the rate at which it is desired to feed soda-ash. This rate is adjustable between 0 and 2,500 lbs. per hour. As the poise is driven inward, the scale beam becomes unbalanced and raises at its outward end. The movement of the weigh beam completes an electrical circuit which starts the feed motor. Material is then fed out of the hopper until the weigh beam is again balanced and the feeder motor circuit is broken. This cycle of operation is kept up until the hopper is empty.

The soda-ash is delivered by the feeder of each hopper into dissolvers which have motor driven paddles. A mixture of water and steam flows through the dissolver all the time it is in service for the purpose of dissolving the soda-ash and delivering it to the water entering the baffled mixing chamber under the floor of the chemical storage house.

The soda-ash is actually weighed out by this feeding equipment. It is in this respect, therefore, different from most of the dry feeding machines used for feeding water softening and purification chemicals by volume and it is felt that the results obtained by weighing are more accurate and dependable.

This feeder or any other feeder will go through the motions of feeding without feeding at all. And, that is what would happen if the soda-ash did not flow to the feeder. To forestall this possibility, a tell-tale has been provided at the end of each weigh beam. If the soda-ash does not flow from the bin the beam of the scale becomes unbalanced as the poise moves inwardly. This upward travel of the beam upsets a mercoid switch which cuts in a warning siren which continues to make its self heard until an operator shuts it off or eliminates the cause of the improper feeding.


Extension Lever of Weigh Hopper
Tell tale indicating Soda-Ash is not feeding from Hopper
Scale Beam calibrated 0 to 10000 lbs.
Feed adjustment device
Poise drive mechanism
Mercoid Switch for making and breaking circuit which stops and starts Feeder
How Scale Operates
1. Poise is set to balance weight of Soda Ash in Hopper.
2. Poise is driven inward on beam at desired rate
3. Inward movement of poise unbalances scale beam completing electrical circuit which starts feeder
4. Discharge of Soda from Hopper causes scale beam to again balance, thus breaking contact and stopping Feeder
5. This cycle continues until Hopper is empty
SCALE BEAM - SODA ASH HANDLING EQUIPMENT
SHEET 5

Scale Beam Arrangement on Chemical Feeder, Columbus, O.

Economy of the New System

The pneumatic conveying system was guaranteed to handle 5 tons of soda-ash per hour, and delivers regularly between 7 and 8 tons. It is therefore possible to set a carload of soda-ash, and unload it completely in one day. The system operates under suction so there is no dust nuisance anywhere, and the cloth filters prevent the loss of any material through the vacuum pump. One operator at the intake nozzle constitutes the only manual labor required, and the whole system is simple and convenient to control.

The present estimated annual consumption of soda-

ash at the Columbus plant is 3,000 tons, which means a direct saving of $7,500 per year through the use of the new system. On this basis the cost of the complete change will be liquidated in about 15 months. In addition, the water plant is more modern, working conditions are improved, and operating costs will be lower in the future.

The plant was designed in the Water Division of the city. The Downing & Hetrick Co., Columbus, O., were the general contractors. The unloading equipment was furnished by the Dust Recovering & Conveying Co. (Now operating as the Dracco Coporation), Cleveland, O., and the chemical feeding devices by the French Oil Mill Machinery Co., Piqua, O.

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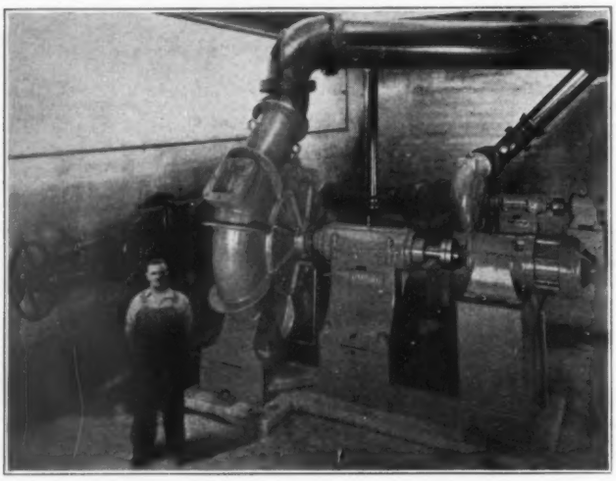
Economy of Operating Low Head Sewage Pumps With High-Speed Motors

By CHARLES YEOMANS
President, Yeomans Brothers Company, Chicago

AS is well known to every centrifugal pump designer, to obtain high efficiencies on low head work, pump speeds must be kept down. Conversely, in the operation of polyphase motors such as are ordinarily used for driving such pumps, the highest efficiencies and maximum power factors are obtained at high speeds. Fortunately,



Two of the Five Yeomans Non-Clogging Sewage Pumps Installed for the City of Oshkosh, Wis. Driven by Allis-Chalmers Motors Equipped with Falk Speed Reducers.

the recent development of the geared-head motor makes it possible to produce a compact pumping unit in which the maximum economy in power consumption can be obtained in both pump and motor—this, despite the slight transmission loss through the reduction gears.

Two pumping stations built by the city of Oshkosh, Wis., recently in connection with a sewerage system designed by Greeley & Hansen, Consulting Engineers, of Chicago, serve to demonstrate the desirability of pumping equipment of this type. The ratings and performance of the geared units in these stations (see illustration) are as follows:

G.P.M.	Head	Motor H.P.	Motor R.P.M.	Pump R.P.M.	Pump Efficiency %
2080	20 ft.	15	1750	580	75
3470	22 ft.	30	1750	490	78
2080	10 ft.	10	1750	360	79
6950	12 ft.	30	1750	243	79

Comparing the efficiency and power factor of the geared-motor, furnished with the second unit listed above (including gear losses), with that of a direct connected motor running at the pump speed of 490 RPM, reveals the following:

30 H.P. (1750-490 R.P.M.) geared motor—Full load efficiency ..... = 88.7%
Power factor ..... = 91.5%
30 H.P. (490 R.P.M.) motor direct connected—Full load efficiency ..... = 84%
Power factor ..... = 72%

Now if one should undertake to improve the motor efficiency and power factor by driving the pump with a direct connected motor at 850 RPM there would result some improvement in motor efficiency and power factor over that of the 490 RPM motor; but, we would at the same time have a drop of 8 to 10 per cent in pump efficiency. Therefore, it becomes quite clear that considering all phases of the problem the geared-motor is to be preferred under these conditions. And, comparing the overall efficiencies of pump and motor in the three alternate arrangements one will find about the following:

With 1750-490 R.P.M. geared motor..... 69.2%
With 490 R.P.M. direct connected motor..... 65.5%
With 850 R.P.M. direct connected motor..... 60%

When further considering the fact that the first cost of a 1,750 RPM motor (including the gear set) is less than that of a 490 RPM motor, without gears, the argument for the geared-head motor drive becomes still stronger.

The motors are of Allis-Chalmers make, equipped with Falk helical gears running in oil. There is no objectionable vibration or noise created, even though the pumps and motors in the Oshkosh station are mounted on welded steel bases and the motor frames are very small in comparison to the pump casings. The bases are built up under the motors to a rather high box section and this condition might be expected to amplify any gear noise.

The pumps are Yeomans Type "HNC" equipped with two-port (enclosed) non-clogging impellers and double Timken tapered roller bearings.

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Water Sales Subject to Sales Tax in Illinois

The State Department of Finance of Illinois has issued a ruling that water sales are subject to the 2 per cent state sales tax. The ruling follows:

"Water companies engaging in the business of selling or furnishing water to consumers are liable for retailers' occupation tax with respect to their receipts from such sales, whether furnished on meter or flat rates. In instances where such companies enter into contracts with municipalities or private persons, under which the water company agrees to furnish water at all times, to be made available through hydrants, and the consideration therefor is a specific amount to be paid by the purchaser of the water per hydrant per annum, the total receipts from such hydrant rental fees are within the Act, and are deemed to be receipts accruing from the sale at retail of water.

"This ruling applies with equal force with respect to municipal water companies as it does with respect to private companies."

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F. W. Gilcreas Joins N. Y. State Department of Health

F. W. Gilcreas, formerly chemist with Weston and Sampson, Consulting Engineers of Boston, Mass., has accepted the position of Chief of Chemical Laboratory in the Division of Laboratories and Research, N. Y. State Dept. of Health, Albany, N. Y. Mr. Gilcreas takes over the duties of the late L. M. Wachter.

PERFORMANCE OF DEARBORN'S CHEMICAL SEWAGE TREATMENT PLANT

Results of a 30-Day Test of the Laughlin Process and Screen Filter

By A. M. BUSWELL, Ph. D.

Chemical Engineer, Urbana, Illinois

CHEMICAL treatment of sewage has been employed to a limited extent for more than fifty years, but the process has not aroused much general interest until the last two or three years.

Earlier investigations, dating about 1905 to 1910, indicated that chemical coagulation was not capable of producing more than about a 60 per cent purification of the sewage even with rather large dosages. The percolating or trickling filter was capable of 75 to 85 per cent purification and was therefore preferred where a high quality effluent was required. The compactness and low first cost of chemical treatment plants was attractive, but the cost for chemicals, together with the inferior quality of the effluent, turned attention away from this process.

The development of the activated sludge process about twenty years ago gave promise of affording a compact installation, low in first cost, capable of turning out an effluent of highest quality. The idea of purifying sewage by blowing air through it caught the popular fancy and "activated sludge" took the center of the stage to the practical exclusion of attempts to improve other processes.

Within the past few years, however, a renewed interest in chemical precipitation has appeared. The difficulties encountered in obtaining uniform results with the activated sludge process and the cost of conditioning and drying the sludge are partly responsible for this shift in interest. Equally important factors are the outstanding advances in the chemistry of coagulation and the improvements in manufacture of chemicals, which have made possible the production of certain coagulants at a fraction of their former cost.

Briefly, the developments in chemical coagulation, resulting from research in the water treatment field, may be listed as follows: 1. Adjustment of the hydrogen ion concentration for optimum coagulation. 2. Introduction of gentle stirring to promote floc formation prior to sedimentation. 3. Introduction of some inert material to weight the sludge. 4. Return of the precipitated sludge. 5. Decrease in cost of ferric salts. 6. Use of liquid chlorine. With these means for improving precipitation at the chemists' disposal, it is but natural to expect that modern results from the chemical treatment of sewage should surpass those of a quarter of a century ago.

One of the interesting recent applications of chemical treatment is to be found at Dearborn, Michigan, where is practiced a combination of chemical coagulation with lime, ferric salts and paper pulp; sedimentation; and, rapid filtration through a Laughlin magnetite sand screen. The Dearborn plant and its operation have been described in previous papers[1][2] which pointed out that the local problem was primarily one of sludge treatment rather than sewage treatment. The installation handles the sewage from about 12,000 people plus the sludge from the sewage of 147,000 people. The sludge is thickened by decantation, conditioned with lime and filtered on Oliver filters, the cake being hauled to a dump. The amount of sludge was so disproportionate to that encountered under normal conditions that published operating data[2] can scarcely be interpreted in terms of what the process would do when treating sewage alone.

In order that data on chemical precipitation and the Laughlin filter might be obtained, which would be of general interest and applicable to normal situations, the writer was asked to assist in formulating an operating schedule for the Dearborn plant which would provide for separating the treatment of domestic sewage from that of sludge treatment. The schedule as planned was followed for one month (October 28 to November 29,

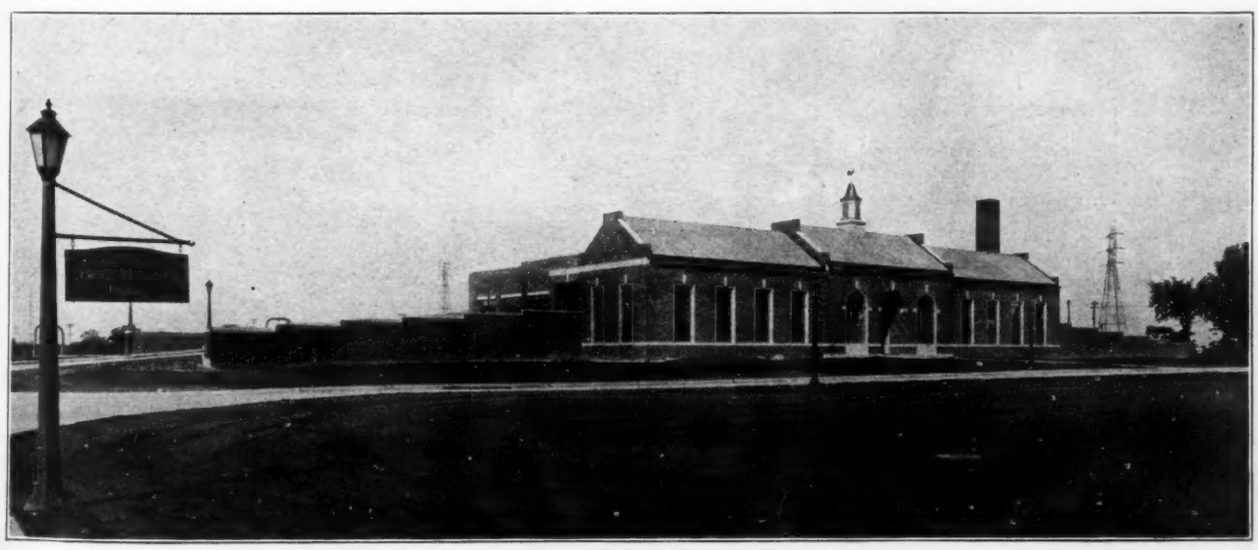

Fig. 1. West Side (Chemical) Sewage Treatment Plant, Dearborn, Mich.

1933), during which time an extensive sampling and analytical program was carried out.

General Description of the Dearborn Plants

The city of Dearborn, Michigan, has two sewage treatment plants in operation, serving a combined population of 159,000.

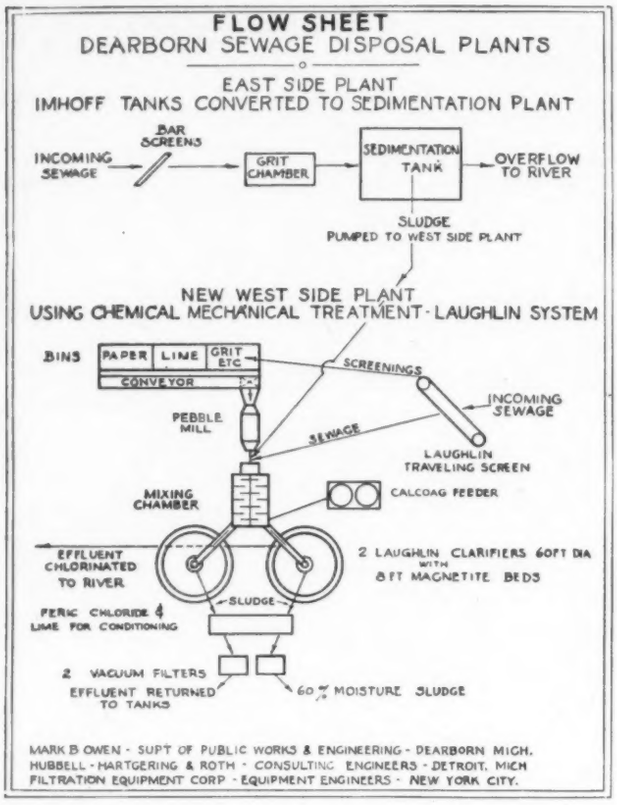

Fig. 2—Flow Sheet, Dearborn Sewage Treatment Plant, Shown in Plan.

In 1932 the original Imhoff tanks of the East Side Plant were converted to plain sedimentation tanks, the sludge from which has since been pumped about 3 miles, through an 8-inch pipe line, to the new West Side Plant, which makes use of the Laughlin process of chemical-mechanical treatment. The plant, placed in operation in March, 1932, was designed and built under the direction of Mark B. Owen, Superintendent of Public Works and Engineering, and the firm of Hubbell, Hartgering & Roth of Detroit, served as consulting engineers. It was designed for an ultimate capacity of 60 m.g.d. with complete pumping equipment for this purpose installed. Two Oliver vacuum type filters with a capacity of 40 m.g.d. are in service and the remainder of the present equipment is designed to handle a combined sewage and sludge flow of 8 m.g.d. Completely equipped, this plant cost $478,853.

The various units of equipment which comprise the plant and the several steps in the process are indicated in the two accompanying flow diagrams (Figs. 2 and 3).

Arrangement for Test

Normal operation of the plant was changed during the test run. The treatment of East Side sludge and West Side sewage were separated, the sludge being conditioned in the No. 2 Laughlin unit, leaving the No. 1 unit for handling the West Side domestic sewage alone.

The flow of 1.7 m.g.d. from the West Side sewer, being considerably less than the 4 m.g.d. rated capacity of No. 1 clarifier, was supplemented by pumping crude sewage from the East Side Plant to the West Side Plant through the pipe line used ordinarily for the transfer of sludge.

Strength of Sewage and Flows

During the 30-day test the influent to No. 1 clarifier, which consisted of about 1.7 m.g.d., West Side sewage, 0.7 m.g.d. East Side sewage, and 35,000 gallons per day of sludge filtrate, on the 19 days when the Oliver filters were in operation, had an average 5-day B.O.D. of 113 p.p.m. with a maximum of 226 and a minimum of 69.

The gravity sewage and the pumped sewage discharged to a common wet wall from which it was pumped to the influent channel of No. 1 Laughlin unit by one or more pumps arranged to cut in or out automatically with the change in depth of water in the wet well. The average flow during the test period was 2.4 m.g.d. and a typical daily pumping record showed a rate of 3.2 m.g.d. from 8 o'clock in the morning to 4 in the afternoon, and 2.1 m.g.d. from 4 p. m. to 8 a. m. The maximum rate recorded was 4.25 m.g.d. and the minimum was 0.8 m.g.d. The flows were measured and recorded by a Simplex-Venturi meter which was cleaned and checked at the beginning of the experiment.

Chemicals and Chemical Feed

Lime and Paper: The lime used was high calcium (pebble) lime until November 22—hydrated lime being used thereafter. Paper pulp was made from waste paper collected from schools and elsewhere.

At two locations in the floor between the lime and paper bins are two scales for weighing lime and paper. The required weight of lime and paper is delivered every 5 minutes by mechanical conveyor to the feed hopper of one of the pebble mills. These mills, cylindrical and similar to concrete mixers, are driven by 10-hp. motors and revolve at about 22 r.p.m. The re-

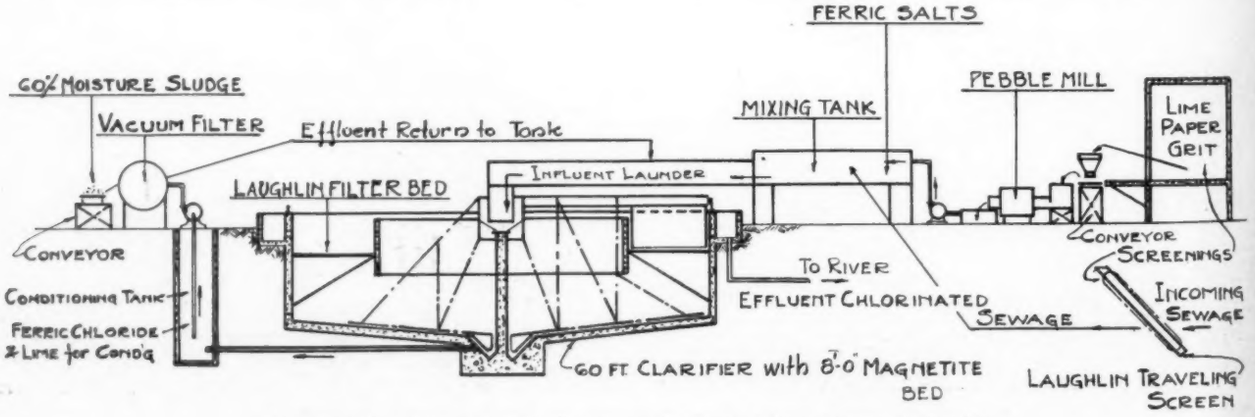

Fig. 3—Flow Sheet, Dearborn Sewage Disposal Plant, Shown in Profile.

sulting mixture (slurry) passes to sumps from where it is pumped by self-priming Nash-Jennings pumps to the incoming sewage as it passes through a baffled mixing chamber. (See Figs. 2 and 3.)

Coagulants: The coagulant used for the first 16 days of the test was ferric chloride, purchased as a solution containing 42 to 44 per cent ($FeCl_3$). The solution was fed through a glass orifice with manually adjustable head, the rate of feed being checked by collecting timed samples and determining the iron content. During the last 14 days "Calcoag" [a soluble (dry) ferric sulfate, containing 75 per cent $Fe_2(SO_4)_3$] was used. It was fed dry to a solution tank, the rate of feed being controlled by a photo electric cell which in turn controlled the speed of a motor operating the usual type of horizontal revolving feeder disc. Since this feeder is still in the experimental stage of development, the rates of feed were double checked against the weight of "Calcoag" added to the machine hopper.

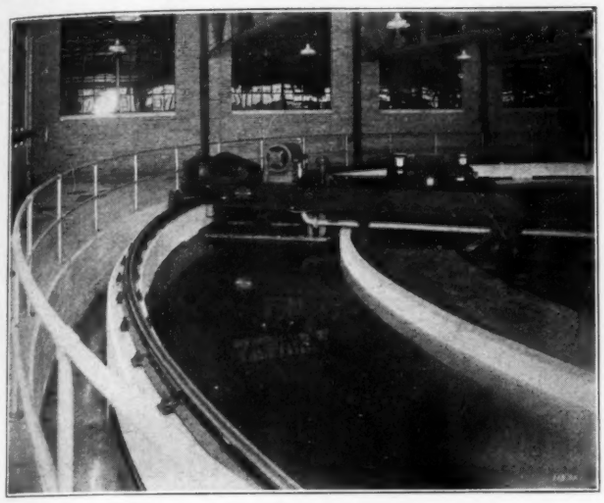

Fig. 4. Laughlin Up-Flow Screen Filter and Continuous Automatic Traveling Cleaner. (See Fig. 5 for Section of Filter and Cleaner in Detail).

The lime feed was regulated to produce, as nearly as possible, a coagulated sewage having a pH value of 7.8 to 8.0. Hourly or half-hourly colorimetric pH tests were made by the operator and the lime feed regulated accordingly. The dosage of coagulant and waste paper was varied to produce the desired quality of floc particles and clarity of effluent.

Mixing: The crude sewage is discharged into a chamber 24 ft. long, 4 ft. wide at the top, and 1 ft. wide at the bottom. Seven transverse baffles equally spaced on alternate sides give the liquid a short but vigorous mixing before discharging into a channel 1½ ft. wide and 36 ft. in length which leads to a down pipe at the center of the clarifier, equipped with a Laughlin filter unit. (See Figs. 1 and 2.)

Clarifier and Filter: The Laughlin Clarifier, with filter, is a circular sedimentation tank (60 ft. in diameter, 10 ft. deep at the outside and 12 ft. deep at the center) equipped with a Type K Dorr traction sludge mechanism adapted to the tank design.

Around the inside circumference of the tank is a shelf-like arrangement 8 ft. wide (see Figs. 4 and 5), which supports a coarse grating on which is placed phosphor bronze screens with 1 m.m. openings. The screen supports a 3-inch deep bed of crushed magnetite [magnetic oxide of iron] graded between No. 10 and No. 16 mesh screens.

Coagulated sewage enters the tank at the center through a 7 ft. circular down draught tube and flows radially outward and upward through the bed of magnetite on the Laughlin filter. The clarified and filtered effluent passes over a number of weirs, in the outer wall and into a collecting channel that completely surrounds the tank. There is a loss of head of two or three inches through the magnetite and this is utilized in washing the bed.

For washing the filter a very unique device was developed. A bronze cleaner case as long as the filter bed is wide (4 ft. 6 inches) is suspended from the frame work of the sludge scraper truss. (See Figs. 4 and 5.) The top of the case is a few inches above the surface of the liquid. In the bottom is a longitudinal opening over which is mounted a long bronze enclosed Cutler-Hammer solenoid, with the winding about a vertical axis. The solenoid is as long as the cleaner case; is about 18 inches wide and covers a narrow sector of filter bed. As the cleaner travels over the surface of the filter the solenoid is periodically energized by direct current. When energized it picks up violently a narrow sector of magnetite. The uprushing liquid (clarified sewage under the few inches head) from beneath the screen scrubs and cleans the lifted portion of the bed and then overflows the cleaner case into a side compartment from whence it is pumped back to the coagulated sewage entering the tank. The magnetite drops immediately when the solenoid is de-energized and is trowelled down smooth by the traveling cleaner case. The amount of sewage passing as wash water cannot be easily measured but has been variously estimated to be 5 per cent of the total flow. The solenoid operates at the rate of 16.9 cycles per minute and the clarifier mechanism and cleaner travels completely around the filter in 33 minutes.

The capacity of the clarifier is based on the filter area and not detention period. The filter is rated at 2.33 gals.

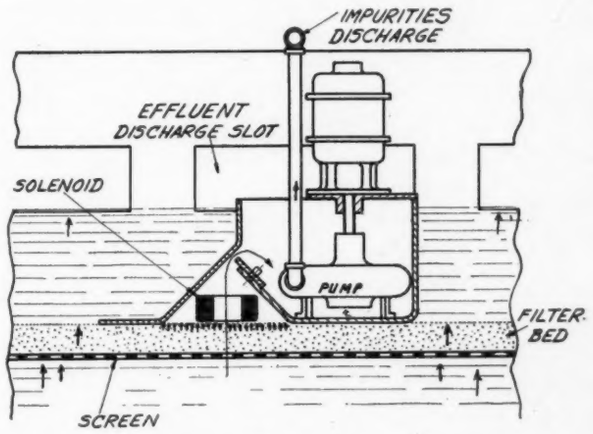

Fig. 5. Laughlin Filter Bed Cleaner.

per sq. ft. per min. (capacity of unit 4 m.g.d.) and the theoretical detention period in the clarifier is 1 hour 10 min. At the average rate of 2.4 m.g.d. the theoretical detention was 2 hrs. and the filter rate 1.3 gal./sq.ft./min.

Sludge Dewatering: Sludge is drawn out daily from the sump at the center of the clarifiers to large sludge sumps and is then pumped to the vacuum filters for dewatering.

The Oliver filters are 8 ft. in diameter by 12 ft. face and have 300 sq. ft. of filter area. The cake, removed by a scraper, is carried by conveyor belt to two bins—one inside the building and one outside—and thence by industrial railroad to an outside dump and by trucks to farms and golf courses. The plant is to be equipped with a Herreshoff type furnace for incineration of sludge cake.

Sampling Schedule and Laboratory Tests

Samples of the influent and effluent were taken hourly in pint fruit jars, sealed and stored in an ice box having a temperature of 40 to 45 F. Experiments indicated that 16 per cent of the effluent B.O.D. may be satisfied during collection if the samples are held in a large container at room temperature. Cold storage of hourly samples was therefore considered essential.

At the end of each 24-hour period (8 a. m.) amounts of each sample proportionate to the flow as recorded by the Simplex meter for the hour at which the sample was taken, were withdrawn and added to a suitable bottle for a composite 24 hr. sample. This sample was submitted to the usual tests, the results of which are shown in Table *II*. All tests were carried out according to "Standard Methods" of the A.P.H.A. and A.W.W.A. with the exception of turbidity. This test was made with a very convenient turbidimeter employing a photo electric cell to measure the light transmitted by the sample. The galvanometer had been calibrated against a standard turbidity suspension to read direct in p.p.m.

Since the amounts of chemicals added were not sufficient to raise the pH of the effluent to the bacteriacidal range it was not necessary to acidify before diluting for the B.O.D. test. As a precaution the B.O.D. dilutions were seeded with settled sewage, a blank being run to correct for the oxidizable matter in the inoculum.

The dilution water was made up every day to be used the following day. Eight liters of distilled water were vigorously aerated with compressed air for 30 minutes. Sodium bicarbonate to the extent of 300 p.p.m. was then added, and the solution seeded with 100 cc. of effluent from the East Side Plant, which had been filtered through coarse filter paper. The water was mixed thoroughly, tightly stoppered and allowed to stand overnight before being used, at which time it contained on the average about 8 p.p.m. dissolved oxygen.

Results

The results of the experiment are presented in Tables I and II. Table I shows that a total of 71.87 million gallons of sewage were treated during the 30-day test run, or an average of 2.4 m.g.d. The maximum daily rate was 3.49 m.g.d. and the minimum 1.64 m.g.d. The lime used averaged 220 lbs. per million gallons, varying from a maximum of 381 to a minimum of 113, the variation being due in part to the necessity for taking care of occasional amounts of acid wastes. The coagulant, in terms of iron (Fe), averaged 86 pounds per million gallons and varied less widely than the lime. The paper feed was kept at about 160 lbs. per million gallons except when difficulty with the pebble mill interrupted the feed. The average was 153.5 lb./m.g. From Table II it is seen that the final effluent had a pH appreciably below 8 and an alkalinity slightly below that of the crude sewage. The turbidity of effluent varied from 12 to 50 for the twenty-four hour composite samples with an average of 24. The settleable solids which averaged 3.2 c.c. per liter in the raw sewage were reduced to a trace in the effluent and the suspended solids determined gravametrically (Gooch crucible) were reduced from 226 in the raw to 18 in the effluent, a reduction of 92 per cent. The suspended solids showed a loss of only 55 per cent on ignition and under microscopic examination were found to contain a considerable amount of paper fiber. Both the oxygen consumed (digestion with permanganate) and B.O.D. show the same percentage purification—namely, 75 per cent. The B.O.D. figures will probably be regarded as the more important and these

TABLE I.—DATA ON PLANT OPERATION WITH RAW SEWAGE
Dearborn, Michigan, November, 1933

		Lime Feed				Coagulant				Paper	
Date	Flow m.g.d.	CaO in Filtrate	CaO Fed lbs.	Total CaO	CaO lbs. per m.g.	Total lbs.	lbs. per m.g.	Calc. as Fe Total lbs.	Calc. as Fe lbs. per m.g.	lbs. per day	lbs. per m.g.
					FeCl₃						
Oct. 30	3.24	174	686	860	265	567	175	195	60.2	320	99
Oct. 31	3.49	340	417	757	217	515	147	177	50.6	584	167
Nov. 1	3.13	308	181	489	156	485	155	167	53.4	576	184
Nov. 2	2.12	314	308	622	293	445	210	153	72.4	576	272
Nov. 3	3.18	194	288	482	151	742	233	255	80.4	96	30
Nov. 4	1.70	...	504	504	296	640	377	220	129.8	378	222
Nov. 5	2.53	...	286	286	113	615	243	212	83.7	352	139
Nov. 6	2.30	260	171	431	187	548	238	189	82.0	576	250
Nov. 7	2.06	...	450	450	218	697	338	240	117.0	184	89
Nov. 8	2.41	270	226	496	206	626	260	216	89.5	...	...
Nov. 9	1.88	...	290	290	154	510	270	176	93.0	42	22
Nov. 10	2.30	279	212	491	213	603	262	208	90.2	348	151
Nov. 11	2.20	...	331	331	150	510	232	176	79.8	540	245
Nov. 12	2.69	...	403	403	150	685	255	236	88.0	471	175
Nov. 13	2.38	277	222	499	210	566	236	195	81.3	232	98
Nov. 14	2.41	176	200	376	151	601	252	207	87.0	298	124
					Calcoag						
Nov. 15	1.64	274	142	416	253	816	497	171	104.	245	149
Nov. 16	2.58	262	302	564	219	1,068	415	224	87.2	252	98
Nov. 17	1.94	...	360	360	185	1,302	670	273	141.	382	197
Nov. 18	2.42	...	379	379	157	1,067	441	224	92.6	336	139
Nov. 19	2.01	...	230	230	115	917	456	192	95.6	336	167
Nov. 20	2.33	277	312	589	253	909	390	191	81.8	358	154
Nov. 21	3.40	140	496	636	187	1,235	373	259	78.2	430	126
Nov. 22	2.20	236	380	616	280	1,078	489	226	103.	360	164
Nov. 23	2.14	177	443	620	290	940	439	197	92.2	398	186
Nov. 24	2.00	251	368	619	310	694	346	146	72.6	360	182
Nov. 25	2.37	...	548	548	231	596	252	125	52.6	360	152
Nov. 26	2.17	...	565	565	260	845	390	198	81.8	360	161
Nov. 27	2.26	372	489	861	381	978	432	205	90.5	359	159
Nov. 28	2.39	282	565	847	355	845	390	198	81.8	360	151
Total	71.87	4,863	10,754	15,617	...	...	...	6,051	....	10,469	...
Average	2.40	....	.....	.....	220.2	...	...	201.7	86.44	360	153.5

TABLE II.—ANALYTICAL RESULTS—NOVEMBER, 1933

Date	pH Raw	pH Eff.	Alk. M.O. Raw	Alk. M.O. Eff.	Turbidity Raw	Turbidity Eff.	Set. Solids Raw	Set. Solids Eff.	Sus. Solids Raw	Sus. Solids Eff.	Total Solids Raw	Total Solids Eff.	O_2 Cons. Raw	O_2 Cons. Eff.	B.O.D. Raw	B.O.D. Eff.	Total Fe Raw	Total Fe Eff.	Rainfall Inches
Oct. 30	7.6	8.0	252	216	550	20	7.0	Trace	400	18	838	514	..	..	166	29	...	...	.04
Oct. 31	7.6	7.8	248	232	475	18	4.5		376	23	838	533	..	..	128	33	...	...	..
Nov. 1	7.5	7.8	254	225	750	33	7.5		512	22	1,028	566	..	..	134	29	...	...	..
Nov. 2	8.0	8.0	246	234	175	17	6.0		142	17	694	591	..	..	80	30*	...	...	.28
Nov. 3	7.9	7.8	208	188	162	32	1.3		91	22	649	556	27	12.5	69	23	...	...	..
Nov. 4	7.5	7.9	238	206	250	20	2.4		213	15	563	343	43	10.8	128	22	2.6	0.8	..
Nov. 5	7.5	7.7	238	236	150	28	1.5		130	24	588	554	47	10.4	87	20	...	...	.01
Nov. 6	7.8	7.8	254	236	190	38	1.7		126	20	732	578	28	12.	110	43	...	...	.05
Nov. 7	7.5	7.8	238	230	900	17	6.0		398	6	752	440	68	11	170	20	...	...	..
Nov. 8	7.6	7.8	254	230	230	23	3.0		173	20	697	570	41	11	109	31	2.8	2.0	.08
Nov. 9	7.3	7.6	216	216	130	17	1.0		68	10	526	506	21	9	73	23	5.6	1.4	..
Nov. 10	7.8	7.8	240	222	125	15	2.0		159	5	695	263	33	9	113	27	4.8	2.4	.07
Nov. 11	7.4	7.8	234	230	145	19	1.6		131	18	613	558	33	10	75	20	2.8	2.8	.35
Nov. 12	7.4	7.8	216	232	215	25	5.0		189	22	735	632	27	12	99	20	4.0	4.0	..
Nov. 13	7.8	7.8	244	232	330	30	3.0		211	18	679	506	45	15	148	40	4.8	4.0	.21
Nov. 14	7.8	7.8	232	224	215	20	2.5		137	10	567	480	80	15	100	31	5.6	4.8	..
Nov. 15	8.0	7.9	241	234	173	17	2.7		103	10	575	526	42	15	87	34	5.6	3.2	..
Nov. 16	7.6	7.6	248	235	148	20	1.3		72	12	620	638	47	14	75	32	2.8	2.8	..
Nov. 17	7.5	7.8	222	230	130	12	2.0		74	11	550	547	46	14	70	16	2.8	2.0	..
Nov. 18	7.3	7.3	242	240	220	35	4.0		167	25	423	441	49	15	134	32	3.4	3.4	..
Nov. 19	7.5	7.7	234	222	300	30	3.5		213	21	469	529	55	15	118	23	4.8	2.8	.08
Nov. 20	7.9	7.9	230	224	...	..	1.5		168	22	646	596	48	16	103	39	6.0	2.8	..
Nov. 21	7.4	7.7	206	188	...	..	3.0		233	35	687	527	51	17	90	25	5.6	3.6	.27
Nov. 22	7.9	7.8	218	214	600	25	5.5		388	19	848	603	69	14	162	24	8.0	2.4	..
Nov. 23	7.5	7.9	238	230	1,060	20	12.0		947	14	1,190	586	98	15	226	26	10.0	2.4	..
Nov. 24	7.9	7.9	246	218	220	17	2.5		144	7	740	625	45	16	87	31	6.0	1.8	..
Nov. 25	7.3	8.0	222	204	400	50	8.5		312	34	724	490	62	16	140	37	2.8	1.8	.08
Nov. 26	7.3	7.6	220	216	220	28	1.5		185	18	749	640	48	12	84	17	3.2	2.0	.08
Nov. 27	8.1	7.9	236	214	275	25	2.0		174	8	640	486	49	14	119	35	3.0	1.6	..
Nov. 28	8.0	8.0	244	242	240	34	2.0		167	24	487	587	49	16	113	35	3.6	2.8	.01
Average	7.6	7.8	235	223	318	24	3.2		227	18	685	534	48.3	12.7	113	28	4.5	2.6	..
Per cent reduction			5.1		93		99+		92		22		75		75.2		42		

*Extrapolated from 4-day determination.

show a reduction from 113 in the raw sewage to 28 in the effluent—an improvement of 75.2 per cent, without chlorination.

The effect of the Oliver filtrate on the B.O.D. of the effluent is seen by comparing the average effluent B.O.D. for the days when the filter was not in operation (22 p.p.m.), with the average of 28 p.p.m. for the entire experiment. This increase is attributed to the liberation of amines and other soluble organic products, during the conditioning of the sludge with heavy lime applications, and would not be removed in any considerable amounts by the coagulation process. If these substances had been present in amounts proportional to the actual sewage treated, namely, the filtrate from 2½ tons of sludge a day instead of from 15 to 20 tons per day, an effluent B.O.D. of less than 28 p.p.m. would have been obtained.

Occasional appearance of pickle liquor wastes (ferrous sulphate) in the influent raised the question as to whether they were present in sufficient amounts to make a correction of the coagulant figure necessary. Accordingly, daily determinations of iron were made on the influent and effluent samples from November 8 to the end of the run. The data indicate an average of 4.5 p.p.m. of Fe in the untreated influent and 2.6 p.p.m. in the effluent or a removal of 1.9 p.p.m. Fe in addition to the Fe added as coagulant. Since the amount of iron removed was so small in comparison to the variations in daily iron dosages it is obvious that its effect was negligible.

It was not possible in a 30-day run to determine the optimum iron dosage, within limits sufficiently narrow, to warrant drawing an opinion as to the relative merits of ferric chloride and ferric sulfate as coagulants.

Effect of Magnetite Screen

It is difficult to obtain satisfactory samples for determining quantitatively the effect of the Laughlin magnetite filter. Three 24-hour composite samples, taken by means of a hand plunger pump, from just beneath the screen, showed suspended solids (Gooch) of 64, 70, and 80 p.p.m., respectively. These figures are to be compared with an average effluent value of 18 p.p.m. The amount of solids in the wash water from the filter give another measure of the solids removed by it. Four 24-hour composite samples of the wash water taken from the discharge of the traveling pump, which returns the waste water to the influent, showed suspended solids (Gooch) of 210, 270, 360, and 410 p.p.m., respectively. These data indicate roughly the value of and work done by the Laughlin screen-filter.

Sludge conditioning and filtration were handled during this experiment by the regular operating personnel of the West Side Plant. The writer is indebted to them for the following data which is essential to a picture of the whole process—from raw sewage to a stable effluent and dried stabilized sludge.

During the test run 219,000 lbs. of dry solids were accounted for, as the result of filtration of the sludge from No. 1 Laughlin unit—i.e., about 3,000 lbs. per m.g. Of this, 64,900 lbs. could be charged off as coagulants, paper and inert material in the Prestolite sludge used for sludge conditioning. This leaves 154,000 lbs. of sewage solids removed—i.e., about one ton for each million gallons of crude sewage treated. From the suspended solids determination the dry sewage solids removed was calculated to be 121,000 lbs. This difference is of interest because it confirms previous estimates of the error in the suspended solids determination.

We are glad to express our appreciation to the authorities of the city of Dearborn for their permission to conduct the test run. We acknowledge especially the advice and assistance of Mr. Mark B. Owen, the Director ot Public Works of Dearborn, and his staff; also to Messrs. Hubbell and Roth of the firm of Hubbell, Hartgering and Roth, for the help given in planning the experiment.

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NEW WATER PURIFICATION PLANT AT OTTUMWA, IOWA

By HORACE A. BROWN
Superintendent, Water Works,
Ottumwa, Iowa

THE source of water supply for Ottumwa is the Des Moines River which originates in southern Minnesota, flows across Iowa and joins the Mississippi River at Keokuk.

The drainage area above Ottumwa is 14,430 square miles, the majority of which is highly cultivated farm lands. Many cities and towns are situated along the river above Ottumwa, most of them discharging raw sewage directly into the river. The city of Des Moines with a population of over 150,000 is the largest, and is located between ninety and one hundred miles above Ottumwa by river distance.

The Author

Our raw water fluctuates widely and quickly in turbidity and bacterial counts, and during the summer months large quantities of algae are present, which impart to the water a decidedly strong and disagreeable odor. The bacterial count ranges from a few thousand per c.c. to several hundred thousand per c.c. within a few hours. A maximum count of over 6,000,000,000 per c.c. was reached on one occasion, at a time of very low river flow, when a heavy coating of ice with snow to considerable depth over the ice, constituted, in effect, a refrigerated pipe line from Des Moines to Ottumwa.

The dissolved oxygen in the raw water ranges from three parts per million to between twelve and thirteen parts per million, rarely falling below the lower figure and holding around ten to twelve during most of the time when the water is cool.

Free or excess carbon dioxide is usually present in the raw water and ranges from nothing to fourteen or fifteen P.P.M., the minimum, or entire absence of CO_2 being reached during the summer months when algae is at its greatest intensity. The highest which we have found to date was 14.96, which was reached on February 20, 1933, when the river was at an extremely low flow and frozen over. On this date, because of the ice blanket, the dissolved oxygen was only 4.2 P.P.M.

A total hardness of the raw water of 415 P.P.M., of which 102 P.P.M., was non-carbonate, was recorded in December, 1932, and is the highest recorded since our laboratory was installed.

After considering all phases and angles of the treatment problem we decided to install the following type of plant which was built in 1932 and placed in operation in February, 1933.

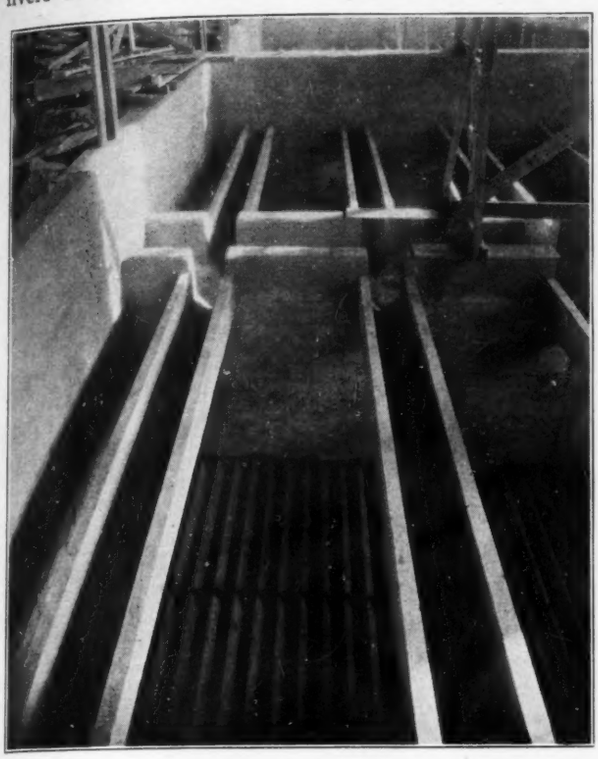
Description of Plant and Process

The plant consists essentially of an intake; raw water pumps; chemical house (containing primary Aeromix, chemical feed machines, and chemical storage); a Flocculator; primary settling basin; secondary settling basin; re-carbonation equipment; re-carbonation settling and receiving basins; 8 M.G.D. filtration plant; low lift clear water pumps to final aerator and activated carbon treatment plant; final filtration, and an 8 M.G. clear water storage basin.

The first step of treatment is to pass the raw water

General View of Softening-Filtration Plant, Ottumwa, Ia. (Hydr o-Electric Plant, Owned and Operated by the Water Works Shows in the Bac k Ground).

through a twenty inch Vogt-Aeromix, which also serves to give a quick mixing of the lime which we add to the water just below the head of the Aeromix which delivers to the Flocculator. Crushed quick lime is fed



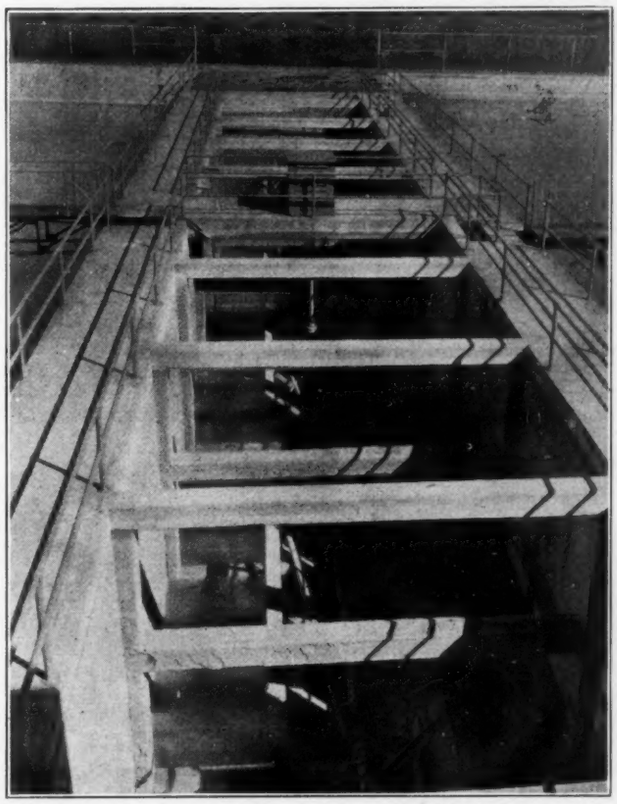
Special Type of Bottom Used in the Filters at Ottumwa; Designed by the Author.

through a dry feed machine into a continuous slaking machine in which a temperature of 180 to 200 degrees Fahrenheit is maintained by the addition of hot water. Lime only is added at this point and in sufficient amounts to maintain a pH of 10.7 at the end of the Dorr Flocculator. This throws down all the magnesia and converts all bi-carbonates into normal carbonates and leaves a hydroxide alkalinity in the effluent of the basin ranging from 20 to 30 P.P.M. and a pH of 10.5. The operator of the chemical house takes tests of the Flocculator effluent each 30 minutes and adjusts lime feed to maintain the desired pH.

The Flocculator consists of a rectangular concrete tank 18x18x115 feet long, with a longitudinal shaft with nine paddle wheels revolving in a vertical plane at three revolutions per minute. This causes the water to travel in a spiral motion as it passes through the Flocculator being retained therein 45 minutes, during which time an excellent floc is developed. From the Flocculator the water passes through a distributing baffle across the inlet end of the primary basin. It consists of one-inch vertical slots spaced ten inches apart; is 90 feet long and 16 feet in depth. After passing the baffle the water crosses an eighty foot (four Dorr arm) Clarifier mechanism supported on and driven from a center pier. Here the bulk of the sludge is deposited and removed. This primary settling basin has an actual detention period of six hours. The primary Aeromix is so connected that the raw water after aeration, can be discharged immediately behind the distribution baffle and into the primary basin without passing through the Flocculator—the thought being that in periods of extreme turbidity preliminary sedimentation could be used prior to giving the water chemical treatment. To date this scheme has not been used.

The outlet from the primary settling basin is through four 18-inch tiles placed four feet below the surface and equidistant around the outlet end of the basin. These tiles connect to a 30-inch vitrified clay line leading back to the chemical house where the water is then treated with soda ash. The amount of soda ash is adjusted to reduce the non-carbonate hardness to between 10 and 15 P.P.M. Enough sulphate of alumina is then added to bring the pH to 9.8, and the water is passed through an "around the end" baffle mixing chamber (20 minutes detention) located under the chemical house which discharges behind a distributing baffle similar to the one just described and into the secondary basin. Connections have been provided so that the effluent from the primary settling basin, if used for preliminary sedimentation, can be treated with lime, soda ash and sulphate of alumina, and passed directly into the Flocculator thence the baffle into the secondary basin. The secondary basin is equipped with a hundred foot (two arm) Dorr Clarifier mechanism mounted on and driven from a center pier. The sludge from this basin can be discharged into the river, as is the sludge from the primary basin, or it can be delivered either into the primary Aeromix or into the "around-the-end" baffle mixing chamber by a return sludge pump. The last named is at the present time the method of operation.

The secondary basin has a detention period of four hours. The effluent from this basin passes through a collecting baffle system which has vertical slots two feet in height and one-half inch in width, the top of this baffle being six inches under water when operating normally. From the secondary basin the water flows to a suction well located outside the basin and adjacent to the filter house. In the filter house is located a low lift centrifugal pump, which lifts the water into another twenty inch



Dorr "Flocculator," Softening and Filtration Plant, Ottumwa, Ia.

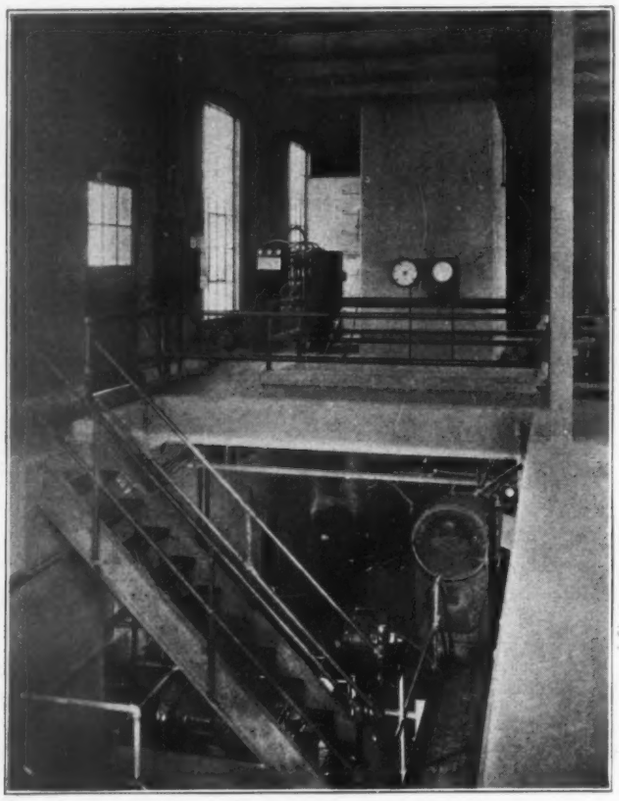
Aeromix which draws in carbon dioxide gas instead of air. The Co_2 is thoroughly broken up into fine bubbles which permeate the water and effectively carbonate it. The carbonated water enters a receiving well from which

it flows into two small receiving basins which are quadrants of circles, one on each side of the filter building and connected to each other by a three foot by nine foot passage way around the end of the filter building.

From these basins the water is admitted direct to the filter units through eighten inch hydraulically operated influent valves located at the back of the filters.

Carbonating Equipment Involves New Use of Aeromix

The CO_2 generating equipment consists of an electrically operated mechanical underfeed stoker burning



Re-Carbonation Equipment and Scrubber, Softening-Filtration Plant, Ottumwa, Ia. "Iron Fireman" Burning Rice Anthracite Coal—"Heggie Simplex Boiler and Condenser, All Located on Pipe Gallery Floor of Filter Building." Scrubber with CO_2 Indicator and Recorder on Operating Floor Level. 20 in. Aeromix in Concrete Tank Behind Scrubber and to Left; Aeromix Discharge Is in Small Tank Outside of Building. Aeromix Unit Sucking in Carbon Dioxide Instead of Air Serves as a Recarbonating Unit.

anthracite rice coal, the boiler has attached to it a condenser for absorption of the heat during the summer months. In the winter months the heat is used for heating the building. From the stack of the boiler all of the flue gas is passed into the bottom of a wet and dry scrubber, being sucked through by the pull of the Aeromix on the outlet end and the forced draft of the stoker under the boiler. A flow-meter is installed in the gas inlet line to the Aeromix and CO_2 indicator and recorder takes samples of the gas at regular and frequent intervals from the flue leading to the scrubber; and, makes a record of the analysis on the same chart that records the volume of gas entering the Aeromix.

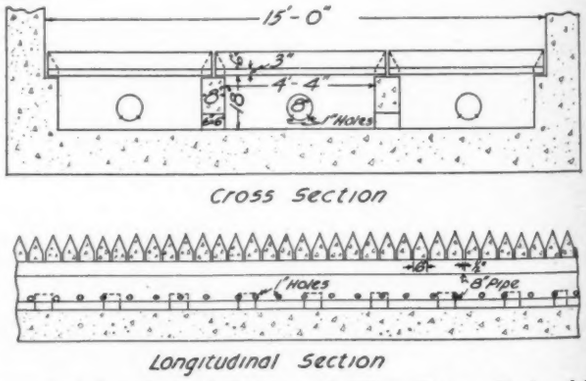
We have found that the volume of flow is very constant, because the water pumped through the Aeromix is maintained at the uniform rate of 5,600 g.p.m. The dosage of CO_2 is regulated by changing the percentage of CO_2 in the gas by manual adjustment of the air control and the rate of coal fed by the stoker. This enables us to operate on the absolute minimum of coal required to generate the needed CO_2 gas, which amounts to approximately 400 lbs. of coal per million gallons of water treated. The filter operator checks the incoming water every 30 minutes and adjusts the CO_2 concentration when necessary, usually requiring but two or three adjustments per day. You will note that the Aeromix takes the place of the usual noisy and troublesome blower required to force CO_2 gas into the water through a pipe grid.

We maintain a residual of about 0.88 to 1.00 P.P.M. of free CO_2 (pH 7.7) in the influent to the primary filters and no complaints have been received nor evidence of red water troubles have been found on the distribution system. Our chemist living near the outer limits of the distribution system carefully watches the water at his home in both the hot and cold water lines and all of our employees have been instructed to be on the watch at their residences for any evidence of trouble of any kind, and to date no traces have been observed either of red water or deposit of carbonates.

We consider it better practice to sacrifice about one grain of hardness, (removal lost in reducing the pH prior to filtration to about 7.7), then to put a large quantity of normal carbonates onto the filters which will result in serious cementing and cracking of the sand and gravel beds, with the final result that the filter beds will have to be replaced at quite frequent intervals. Maintaining a pH of 7.7 in the influent to the filters eliminates all this and results in a much better tasting water, and a water which shows no signs, to date, of being aggressively corrosive.

Filter Bottoms of Local Design

The filters are two million gallon units divided by a central wash water gutter into two one million gallon units, which operate at the rate of two gallons per square foot per minute. The sand used in the filter beds was obtained from Muscatine, Iowa and has an effective size of .38 to .45 millimeters and uniformity coefficient of 1.3 to 1.5 and is 30 inches in depth. The underlying gravel bed is graded from 1/32 inch to 1 and ¾ inches and is 18 inches in depth above the false bottom, the valleys of which are filled with the coarse gravel carefully hand placed.



Cross and Longitudinal Sections of Filter Bottom Designed by Horace A. Brown.

The filter bottom (see illustration) used in the new filters consists of a false bottom made of pre-cast concrete blocks finished with inverted "V" shaped tops. These block are six inches wide at the base and spaced one-half inch apart. They are supported eighteen inches above the real filter bottom by two concrete walls eight inches thick running longitudinally through the filter tank, separating the compartment under the false bottom into three inter-connected separate chambers.

Wash water is supplied to, and the effluent taken from,

these compartments through eight inch cast iron pipes, running the full length of these compartments, drilled with two rows of one inch holes spaced eight inches part. These rows of holes are located in the bottom third of the header pipe so that the force of the jet is directed downward away from the false bottom and against the real floor. This filter bottom seems to provide an excellent distribution of wash water and eliminates all unwashed area in the bottom of the filter.

The dirty wash water from the filters is stored up in a basin under two of the units and is returned to the primary basin through a split suction on the raw water pumps.

Under the remainder of the filter building is a small clear water storage basin from which low lift centrifugal pumps take the water and deliver it to the final Aeromix where final aeration takes place and activated carbon in the amount of 25 to 30 pounds per million gallons is introduced into the clear water. The carbon treated water then passes into a settling basin providing two hours' detention and then through the old rapid mechanical filters at a rate of three gallons per square foot per minute to remove all of the carbon and produce a fine tasting water, sparkling, clear and free from all odors. From these old filters the water enters the clear water reservoir which has a capacity of 8,000,000 gallons.

The water is given a final treatment with ammonia and chlorine in the suction line of the high service pumps which deliver the water to the consumer.

Costs of Treatment and Cost of Plant

In the accompanying Table I is shown average figures for each month indicating hardness removed, volume treated and costs. The table does not show the quick and wide changes in quality of the raw water which make our problem of water purification a difficult one.

It will be noted that the softer the raw water the greater is the cost per P.P.M. of hardness reduction and the higher the hardness of the raw water the lower is this proportionate cost. All of this indicates that the last few remaining parts of hardness are the most expensive to remove.

We drew our own general design of this purification system which was detailed by the engineering firms of Consoer, Older & Quinlan of Chicago, who prepared the working drawings. To them we feel very grateful for suggestions and ideas brought out during their part of the work, and also we feel grateful to Mr. R. Lowe of Proportioneers Inc., for his assistance in working out some of the details of the re-carbonation layout.

Construction was carried out under a contract with Meier Bros. of Ottumwa on the basis of actual cost plus a fixed sum to cover use of equipment and working capital. The actual direction of the work and the method of prosecuting the work was planned by the writer. All labor was taken from the unemployed registration list and so rotated that over 1,400 different men were employed during the construction.

The total cost of this 8 M.G.D. plant, complete, was only $227,832.00; the cost of the 8,000,000 gallon clear water storage basin was $33,296; and the 42 inch cast iron pipe line laid beneath the power canal cost $47,397.

The entire improvement was financed by an issue of Water Revenue Certificates which can be retired only from the operating revenue of the Water Department. No taxes have been levied for Water Works purposes in Ottumwa since 1926.

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Michigan State College Offers Short Course for Sewage Plant Operators

On March 26-28 the third annual Short Course for Sewage Works Operators will be given by Michigan State College at East Lansing, Mich., which will be attended by about 30 operators. The courses, designed for beginners and also for advanced students, are to be given under the supervision of F. R. Theroux, W. L. Mallman and E. F. Eldridge.

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A. W. W. A. Committee to Study Water Supply Code

Malcolm Pirnie, President of the American Water Works Association, has announced the appointment of a committee, composed of Managers and Chief Engineers of Municipal Water Departments, which will make a careful study of the Code drawn by the Water Supply Utilities Institute. The immediate intent is that of cooperation with the Institute to make it attractive for municipalities to operate under the Code.

Evolving ways and means of creating greater stability of employment in municipally operated Water Departments, by protecting efficient and faithful employes against inexcusable loss of position resulting from political changes in local governments, constitutes one feature of the ultimate goal of this committee. In other words, the end to be attained is that of placing positions of responsibility in municipal water works on an even footing with those in the commercial water works industry, where ability is the sole criterion of tenure of position and advancement.

This committee is headed by W. W. Brush, Chief Engineer, Department of Water Supply, New York City, and is composed of W. G. Bank, Newark, N. J.; Seth M. Van Loan, Philadelphia, Pa.; W. W. Hurlbutt, Los Angeles, Calif.; Andrew B. Mauzy, Jersey City, N. J.; Franklin Henshaw, Scarsdale, N. Y., with A. V. Ruggles serving as secretary.

Note: The Code of the Water Supply Industry has been withdrawn by the Water Supply Utilities Institute since the editorial dealing with the Code, which appeared in the last issue of WATER WORKS AND SEWERAGE, was prepared. This action was taken in order to allow the A. W. W. A. committee an opportunity to take part in desired revision of the instrument.—*Editor.*

TABLE I—CHEMICAL COST DATA

1933 Month	Gallons Treated	Cost Per Million Gallons	Hardness Raw Carbonate	Hardness Raw Non-Carbonate	Hardness Final Carbonate	Hardness Final Non-Carbonate	P.P.M. Reduction Carbonate	P.P.M. Reduction Non-Carbonate	Cost Per Million Gallons Per P.P.M. Carbonate Cents	Cost Per Million Gallons Per P.P.M. Non-Carbonate Cents
March	73,106,000	$17.48	201.3	52.7	83.4	16.0	117.9	36.7	8.3	21.1
April	96,853,000	17.62	170.1	65.5	81.3	7.1	88.8	58.4	8.9	17.0
May	117,266,000	17.58	169.8	66.0	69.9	9.3	99.9	60.6	8.5	15.0
June	96,700,000	22.11	205.0	65.4	68.4	5.4	136.6	60.0	7.5	19.8
July	83,810,000	20.46	172.8	55.5	54.0	1.0	118.8	54.5	7.8	20.5
August	72,537,000	18.62	136.1	45.5	57.1	0.8	79.0	44.7	11.7	21.1
Sept.	65,813,000	15.68	129.1	46.0	57.3	9.5	71.8	36.5	11.5	20.2

Sulphate Alumina...$26.40 per ton f. o. b. Ottumwa, Iowa.
Lime ..... 9.00 per ton f. o. b. Ottumwa, Iowa.
Soda Ash ..... 28.80 per ton f. o. b. Ottumwa, Iowa.

CHLORINATION IN SEWAGE TREATMENT

Its Accomplishments and Limitations Reveal Its Value

By A. M. RAWN

Assistant Chief Engineer, County Sanitation Districts, Los Angeles, Calif.

THE cost of sanitary sewage and industrial waste collection and disposal is not always measured by the value of the bonds for construction or the dollars and cents spent for operation. A toll, which cannot be directly evaluated, often manifests itself in one or more of many ways; inconvenience and possible menace to health to groups of citizens, invasion of riparian rights, danger to water supply, accelerated destruction of physical works, and loss of public confidence. These are some of the commoner ones, but there are others of a like order. Any or all of these may result from the construction and operation of a sewerage system, carefully planned and inspired by the needs of public health and public welfare. That such troubles make their appearance is testimony to the fact that some elements in the sanitary science are not subject to specific preliminary analyses but like epidemics must be met as they arise.

Complexities of Sewerage Practices

So many complex factors are involved in the problem of sewage collection and disposal that it is not surprising to find the solution difficult. Sewage characteristics differ somewhat, not only in separate localities, but hourly in the same; its reactions are materially affected by the quality of its water content and the source of its wastes. Temperature, strength, time of transit through the sewers to the point of concentration and velocity of flow exercise a profound influence upon its condition, both as to odors and its disposition to yield to oxidation processes. These variables all compound one with the other to produce disorders in a sewerage system which results in unforeseen difficulties and exact their price.

This sounds a little as though I were trying to persuade you that the design of a sewage collection and disposal system is a venture into the unknown. No such implication is intended. Sewage everywhere has many common characteristics which indicate a general plan of procedure and in the main most systems accomplish their objectives fairly well. But, while they are doing so, the influence of the many variables is at work giving rise to unanticipated troubles and occasionally causing public agencies, responsible for the erection of plants and systems, to not only doubt the wisdom of their venture but, indeed, the very sanity of their technical advisers. The science is advancing rapidly, however, and some day may witness the erection of a plant for which State Health Authorities will have only words of commendation.

One Method of Overcoming Many Difficulties

Without attempting to offer any universal panacea for the unforeseen ills which sewerage systems and disposal plants suffer, this discussion is prepared to relate experience in correcting some of the difficulties encountered and the advantage taken of the ability of a sterilizing element to assist in the job.

Common among the complaints about sewage collection and disposal are those concerning odors. Quite usually odors are the product of decomposition and their principal constituent is hydrogen sulphide. To the citizen whom the offend they mean one thing, to the sanitary official another. The citizen desires their removal promptly because they are disagreeable and react to his discomfort and if they are not supressed he will, at times, employ extreme measures to force their elimination. To the sanitary official, whose nose is probably better attuned to this condition than that of the layman, odor is usually the index of decomposition and he thinks in the terms of potential destruction of system lines and structures and probable difficulties in treatment.

Fresh domestic sewage is not particularly offensive to the sense of smell, therefore, if it can be kept fresh until final disposal there will be nothing to offend the noses of the critical. Sufficient evidence is at hand to conclude that if bacterial action in the sewage is inhibited (effectively retarded), decomposition will progress but slowly and the sewage will remain comparatively fresh. There are a number of laboratory means for retarding bacterial action in sewage but the most common field method is by the introduction of chlorine.

Stale or septic sewage may and probably will give off gases which are extremely offensive. The degree of offense will depend upon many factors, principle among which are, age, temperature, strength and mineral sulphate content of the sewage. The quality and quantity of the odors may be said to vary with any or all of these four factors.

The effects of chlorine upon sewage are manifold. Some of the reactions can only be judged by results, others are subject to analysis. Chlorine is a bactericide with pronounced oxidizing qualities and when sewage is chlorinated to produce a residual of the oxygen demand is materially decreased and the rate of bacterial reproduction effectively retarded for a considerable period. If the bacterial development is restricted and the decomposition phenomena retarded, the effects of age, temperature, strength and mineral content are, to a marked extent, nullified and gases which might normally be produced within a few hours will not appear for many times that period.

The chlorine demand of sewage is quite usually expressed in parts per million. It indicates the amount of chlorine required to enter into reaction with such of the organic and inorganic sewage constituents as may readily combine with it, leaving but a trace of detectable chlorine in the sewage water. The chlorine demand may also be said to vary with the foregoing four factors.

Because the chlorine demand increases with the age of sewage, it should be apparent that from the standpoint of economy, if nothing else, early chlorination is desirable. At just what point on the system chlorine should be introduced is dependent upon the individual system. No set rule can be applied, but the nearer the source it is added, the less it will take to satisfy the chlorine demand, a factor to be equated to the number of chlorination stations which one desires to install and operate in sewer line chlorination.

Other Advantages Than Odor Control

Control of odors is but one of the benefits accruing from the chlorination of sewage. In the system with which I am most familiar, that of the Los Angeles County Sanitation Districts in California, chlorine is ap-

plied for an entirely different purpose. Conditions in the Districts' system are conducive to septicity. The sewage is strong, and in a mixture of domestic and industrial waste of high mineral sulphate content. Its average time of detention in the collecting lines is 15 hours; temperatures are high in summer and only slightly less in winter, sewer grades and velocities are moderate. The resultant of these conditions prior to line chlorination (chlorine application at selected points on the sewer system) was the delivery at the Districts' disposal plant of septic sewage which did not respond readily to an activated sludge treatment process. Chlorine was applied in this instance to stabilize the sewage enroute to the plant. Control of odors was of secondary consideration in this particular instance.

Results in this case were gratifying. Sewage reached the activated sludge plant in such condition that the plant capacity was trebled. The sewage upon arrival was fresh in odor and in fact; strength as indicated by five-day B.O.D. tests was reduced about 25 per cent. Sewers, into which the maintenance forces had previously been unable to venture without gas masks, showed oxygen in abundance after chlorination and the entire system of some 1,200 miles of lines can now be entered in safety at any location. Odor complaints have practically ceased. This illustration, in my opinion, shows quite clearly the direct benefits accruing from the correct and timely addition of chlorine in this instance.

Reduction of Oxygen Demand

For a number of years chlorine has been used in sewage treatment as a bactericide. Its use as an agency to effect reduction in oxygen demand is more recent. Fortunately its ability in the latter operation is not restricted to its power as a direct oxidizer. The introduction of sufficient chlorine into a sewage to satisfy the chlorine demand and leave a slight residual, will reduce the five-day B.O.D. several times its *direct* oxidizing power as chemists calculate potential oxidation by chlorine. Whether this reduction is absolute or merely a slowing down of the rate of oxygen consumption has been debated. Authorities differ, but the most recent evidence is incorporated in a discussion by Levine and Watkins, in which the chlorine derivative of acetic acid is said to exercise a slower rate of oxygen demand than acetic acid. Whatever the reasoning may be, the result is that properly chlorinated sewage is reduced 25 to 30 per cent in strength, as indicated by five-day B.O.D. determinations.

This strength reduction is of importance. Of particular interest to the small city is the fact that conditions in its sometimes overloaded disposal plant, producing an inferior effluent, may be remedied, in whole or in part, by applying chlorine to further reduce the oxygden demand of the effluent, or the sewage strength, and thereby increase the plant capacity. Where disposal by dilution is effected the decreased strength and semi-sterile condition of chlorinated sewage will many times be the deciding factor in the ability of the diluting body to stabilize the oxygen demanding load and preclude putrefaction. Disposal by ponding or by soil percolation is benefited in much the same manner.

Chlorination of sewage has, if anything, a beneficial effect upon sludge digestion. Prominent investigators have demonstrated that the rate of the drop in pH accompanying the first stages of digestion is retarded; a factor of economy. As to accelerating digestion there is some controversy. From the operation standpoint it is satisfactory to know that the benefits of sewage chlorination may be experienced without any ill effects to this important disposal plant function.

There are so many plants using chlorine in connection with industrial waste and sewage disposal and for so many different purposes that this discussion does not permit their enumeration or description. Scarcely an issue of the sanitary science journals does not contain matter descriptive of the application of chlorine at some place to assist in disposal difficulties, and comments upon results obtained are quite universally favorable.

Chlorination of raw sewage in the sewer system is usually for stabilization, odor control or structure protection. For whatever purpose applied, all are benefited although the technique and dosage varies with the purpose. In the plant chlorine may be applied to raw or settled sewage to reduce strength or eliminate odors. Applied to primary settling tank effluent it destroys odors, increases the efficiency of filter beds and when temporarily overdosed, prevents filter ponding and assists in the control of the filter fly. In the oxidizing tanks of the activated sludge plant it apparently has little place although pre-chlorinated sewage, which carries no residual past the outlet of the primary clarifiers, has no injurious effect upon the activated sludge process as such.

The application of chlorine to oxidized plant effluents is usually for the purpose of sterilization; but oxygen demand, if any is reduced. From the plain sedimentation or screening plants the effluent may be chlorinated for strength reduction or retardation of putrefaction; in any event both will be accomplished with the same dose.

Chlorine dosage varies with the chlorine function and chlorine demand and the amount of chlorine to be used will depend upon the job to be performed and the condition of the sewage at the time and place of performance. If maximum reduction of strength is to be accomplished, the full chlorine demand must be satisfied, with a slight oversupply leaving a perceptible residual of chlorine in the liquor. Sterilization of sewage and plant effluents likewise demands full satisfaction of the chlorine demand plus a slight residual. No less amount will be thoroughly effective in either case. A residual of a few tenths of a part per million after a contact period of a few minutes will just about measure the quantity to be used, excepting where large particles of chlorine demanding substances are thickly dispersed through the sewage. For control of odors less chlorine is often required and split chlorination, i.e., chlorination of the same sewage at two or more points, is frequently beneficial. Trial alone can determine this accurately. For control of filter fly and prevention of filter ponding the liquid to be filtered is heavily overdosed with chlorine for short periods and repeated as necessary.

Determination of Chlorine Requirement

There is but one sure way to determine the chlorine demand preliminary to actual installation and operation, and that is to conduct somewhat extensive tests of the sewage over the system. This is a short job if the system is small, but compounds with its size. The Sanitation Districts spent many months in making some ten thousand analyses of sewage in the lines and at the plant prior to temporary location of eight chlorination stations. For a small system, treating domestic sewage, the location of the chlorination point, or points, may be more obvious and the job done in a short time. The general plan of procedure must depend upon the type and magnitude of the system to be investigated but the sampling technique is simple and the tests inexpensive.

A very satisfactory type of line chlorination station is one which can be readily moved from one location to another until the best point of application is found. The permanent and absolutely best location for dosage is quite difficult to determine from a sewage survey. Every one

of the eight line stations in the Los Angeles County Sanitation Districts has been changed at least once, some of them twice and always with beneficial results. Two of them will probably be changed again this summer. The small collapsible, corrugated iron buildings are easily moved.

The recent impetus given sewage chlorination can be largely attributed to the substantial reduction in chlorine price. The reasons for the drop to the current level, of from three to seven and one-half cents (depending upon quantities consumed), I leave to the manufacturers to supply. Nevertheless, at the latter prices, it may be profitably applied in correcting such of the sewage collection and disposal difficulties as it will assist.

Chemical Precipitation Returning to Favor

Chemical precipitation, in sewage treatment, has been recently revived. It was one of the oldest methods but had fallen into disuse through the lack of proper application of principles of coagulation and the expense of coagulants. A better understanding of coagulation and the advent of cheap ferric chloride inspired the construction of a large scale experimental plant at Palo Alto where ferric chloride coagulation followed by sedimentation effected considerably better purification than plain subsidence. Coupled with final chlorination, it produced an unusually clear, odorless effluent, low in suspended solids and high in stability. The use of ferric chloride, and other admixtures in sewage sludge, indicates increased efficiency in sludge filtration and drying.

There are a number of other difficulties in collection and disposal in which chlorine has been used to advantage, but their significance is not so important as those which have been mentioned. A review of the appended references will disclose specific cases in which the application of chlorine, or some combination of chlorine with other compounds, has been effective in eliminating undesirable operation features.

Chlorine is an assistant, to be employed in ironing out the rough spots encountered in sewage practice and in refining treatment plant end produces when the process and facilities employed have failed to produce desired results. The popularity of this reagent for such purposes is pretty good evidence of its efficiency at such tasks.

Acknowledgment—A paper presented before the sixth meeting of the Arizona Public Health Association.

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"Antimony Method of Sulphide Determination," A. J. Salle and E. A. Reinke, *California Sewage Works Journal, Vol. II.*

"Clarification of Sewage with Ferric Chloride," R. A. Stevenson, *Water Works and Sewerage*, March, 1933.

"Control of Sewage Conditions by Chlorination," F. D. Bowlus and A. P. Banta, *Water Works and Sewerage*, November, 1932.

"Generation of Hydrogen Sulphide in Sanitary Sewers," F. D. Bowlus and A. P. Banta, *Water Works and Sewerage*, April, 1933.

"Chlorination Helps Solve Sewage Works Odors and Stream Pollution Problem at Downers Grove, Ill.," H. F. Ferguson and W. H. Wisely, *Water Works and Sewerage*, June, 1933.

"The Regulation of Chlorine Application in Sewage Odor Control," A. E. Griffin, *Water Works and Sewerage*, June, 1933.

Association Meetings Scheduled

March 22-23—**New Jersey Sewage Works Association.** Hotel Hildebrecht, Trenton, N. J. Secretary, John R. Downes, Bound Brook, N. J.

March 29-30—**Michigan Sewage Works Operators Association.** State College, East Lansing, Mich. Secretary, W. F. Shephard, State Department of Health, Lansing, Mich.

April 4-5—**Canadian Section, A. W. W. A.** Hotel Royal York, Toronto, Ont., Canada. Secretary, A. E. Berry, Ontario Department of Health, Toronto, Ont.

April 10-12—**Southeastern Section, A. W. W. A.** Partridge Inn, Augusta, Ga. Secretary, W. H. Weir, State Board of Health, Atlanta, Ga.

April 11-13—**Indiana Section, A. W. W. A.** Memorial Union Bldg., Purdue University, Lafayette, Ind. Secretary, C. K. Calvert, R. R. 3, Box 976-H, Indianapolis, Ind.

April 16-18—**Florida Section, A. W. W. A.** Daytona Beach, Fla. Secretary, L. G. Lenert, Chief Engineer, State Department of Health, Jacksonville, Fla.

April 20-21—**Montana Section, A. W. W. A.** Billings, Mont. Secretary, H. B. Foote, State Board of Health, Helena, Mont. (School for water works operators precedes meeting, April 18-19.)

April 18-19—**Illinois Section, A. W. W. A.** Hotel Pere Marquette, Peoria, Ill. Secretary, A. E. Skinner, Pitometer Co., 5311 Kenmore Ave., Chicago, Ill.

April—**New York Section, A. W. W. A.** Binghamton, N. Y. Secretary, R. K. Blanchard, Neptune Meter Co., 50 E. 42nd St., New York, N. Y.

May 3-4—**Maryland-Delaware Water and Sewage Works Association.** Wardman Park Hotel, Washington, D. C. Secretary, A. W. Blohm, 2411 N. Charles St., Baltimore, Md.

May 10-12—**Pacific Northwest Section, A. W. W. A.** Hotel Eugene, Eugene, Ore. Secretary, E. C. Willard, 720 Corbett Bldg., Portland, Ore.

June 4-6—**Annual Convention of American Water Works Association.** Hotel Commodore, New York City. Secretary, B. C. Little, 29 W. 39th St., New York City.

June 15-16—**New York State Sewage Works Association.** Jamestown, N. Y. Secretary, A. S. Bedell, State Department of Health, Albany, N. Y.

June 25-27—**Pennsylvania Water Works Operators Association.** State College, Pa. I. M. Glace, Secretary, State Department of Health, Harrisburg, Pa.

June 27-29—**Pennsylvania Sewage Works Association.** State College, Pa. L. D. Matter, Secretary, State Department of Health, Wilkes-Barre, Pa.

July 12-14—**Virginia Section, A. W. W. A.** Martinsville, Va. Secretary, H. W. Snidow, State Department of Health, Richmond, Va.

Aug. 23-24—**Central States Section, A. W. W. A.** Hotel Windsor, Wheeling, W. Va. Secretary, H. L. Nelson, U. S. Pipe & Foundry Co., 2435 Koppers Bldg., Pittsburgh, Pa.

Sept. 3-6—**Annual Meeting of American Public Health Association.** Pasadena, Calif. Willimina R. Walsh, Secretary, 450 Seventh Ave., New York City.

Sept. 17-19—**Rocky Mountain Section, A. W. W. A.** Santa Fe, N. Mex. Secretary, B. V. Howe, Board of Health, Denver, Colo.

Oct. 15-18—**Southwest Water Works Association.** Hotel Hilton, Waco, Tex. Secretary, Lewis A. Quigley, Superintendent, Water Department, Fort Worth, Tex.

SEALING ABANDONED COAL MINES

A Federal Project to Protect Public Water Supplies

By B. F. HATCH*

FOR a number of years mine drainage of an acid character has ruined streams for water supply purposes or has added to the difficulty and expense of purification. And, in other ways, has destroyed the value of streams.

During the summer of 1933 mine drainage entering the Ohio River and its tributaries was responsible for the appearance of free acid as far down stream as the confluence of the Muskingum and the Ohio and seriously affected the water supply of some 5,000,000 people residing in the Ohio valley.

The urgent need of taking steps to reduce mine drainage has been recognized by the Federal Government as evidenced by an allotment of $1,500,000 of CWA money to be used for curtailment of such pollution by sealing abandoned coal mine openings. These funds are being expended under the supervision of the U. S. Public Health Service and have been apportioned among the several states, on the basis of the relative number of openings to be sealed. The work is progressing in each state under the direction of the State Health Officer through an administrative and supervisory organization composed of mining engineers. The working force is made up of mining men recruited from the ranks of the unemployed. The U. S. Bureau of Mines and the mining bureaus in the several states are cooperating in an advisory capacity in regard to technical details and safety methods.

While coal companies actively engaged in mining operations have cooperated in attempting to correct and prevent acid mine drainage in some states, notably Pennsylvania and West Virginia. In these two states, where studies of methods of handling mine drainage have been in progress for the past several years, the industry as a whole has generally taken the position that little permanent benefit can result from corrective measures at active mines until the pollution caused by drainage from abandoned mines is eliminated. Affixing the responsibility for pollution from the latter has been difficult if not in many instances impossible.

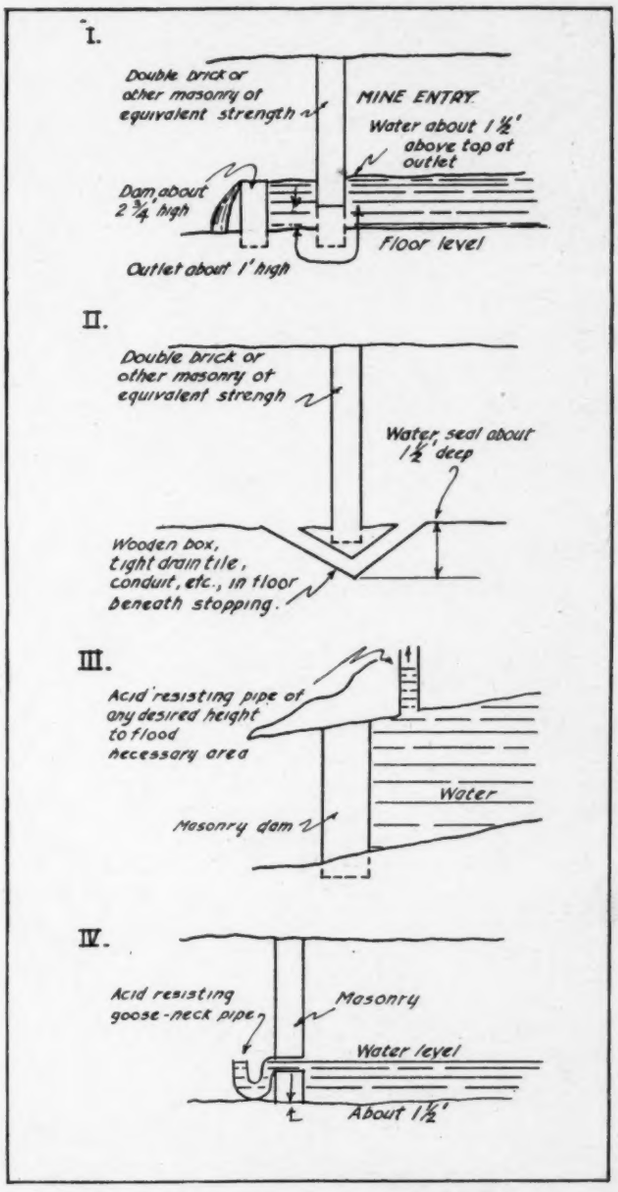
Theory of Acidification of Mine Drainage

At the suggestion of the U. S. Public Health Service, the U. S. Bureau of Mines inaugurated a study of the mine drainage problem in 1924. The conclusions reached —and substantiated results from actual sealing operations in Pennsylvania and West Virginia—are to the effect that exclusion of air (oxygen) from mine workings will subdue or eliminate oxidation of pyrites (sulphide of iron) which is the source of the sulphuric acid and ferrous iron in mine drainage. If so, the drainage which originates largely from water percolating through the mine roof will be a normal ground water, differing little in character from the water that might be expected if no mining operations had been carried on. Based on these assumptions the sealing of mine openings appears to be the most practical solution to the problem.

Methods of Sealing Openings

Several different methods of mine sealing will be employed. Dry openings such as shafts, drifts or stopes from which no drainage normally flows will be entirely closed with airtight stoppings either of earth or masonry. In some cases where the cover is suitable and of sufficient thickness such openings may be closed by blasting. Where the overburden is of a rocky nature or is of insufficient depth to render sealing by blasting practical the openings will be closed by construction of masonry barriers constructed of brick, concrete or stone.

Openings from which drainage is flowing are being sealed in such manner as to exclude air but to permit the normal outflow of water. It is usually essential that water levels be maintained at or near their present elevation. Otherwise, the building up hydrostatic heads may cause damage to adjoining underground or surface properties. On old shafts, filled with water, nothing is



Schemes for Sealing Mines (Side Views)

*Assistant Director, for Ohio, Federal CWA Project, Sealing Abandoned Coal Mines.

necessary except to construct an adequate cover. Such construction usually involves only a concrete slab reinforced with old mine rails or similar material. In slopes where the elevation of the water in the mine workings is sufficiently high to reach the mine roof, at some point near the outlet, an effective air seal has already been established by nature. No work needs to be done on such openings unless the decrease in water level in the dry season brings about a natural passage of air through the mine.

In drift openings air seals are procured by the construction of a low dam at a suitable point across the mine entrance, together with the construction on the mine side of the dam of a baffle extending down from the roof to a point sufficiently below the crest of the dam to form a trap or water seal—(see sketches). This type of construction permits normal water flow from the opening but prevents the entrance of air without materially raising the hydrostatic level in the mine workings.

It is rather important in most sealing operations to avoid flooding the old workings if this can be prevented. The old workings often contain a number of "gob" areas from which a considerable amount of acid may be leached if flooded.

In some cases the soil cover over old workings is quite shallow. Normally a considerable amount of air reaches such workings, by the process known as surface "breathing," in spite of sealing structures. This interchange of air occurs through cracks in the surface with changes in atmospheric pressure. In such cases the only effective method of sealing is to flood the old workings by building a complete barrier to the full height of the drainage openings. The hydrostatic pressure developed by such construction is relieved by removing the mine water at a point above the roof of the mine through an overflow channel on top of the masonry barrier—(see sketches).

Anticipated Results

Mine sealing, in addition to correcting water supply damage, will render smaller streams fit for stock watering and water in larger streams satisfactory for recreational and industrial purposes.

In most cases the effect of the sealing operations will be noticeable only after a considerable lapse of time. Before a material improvement can take place, drainage now in the old workings must be displaced and oxygen now in the workings must be exhausted before oxidation of the pyrites is noticeably checked.

In order to have a record of the improvement effected by this project sampling stations, suitably marked by permanent concrete posts, are being established at all drainage openings. Samples of the mine drainage flowing from such openings are being collected and analyzed for total acidity or alkalinity, free mineral acid and ferrous and ferric iron content. Flow measurements are made at each drainage opening and entered as a part of the permanent record. On tributary streams, heavily polluted by mine drainage, sampling stations have been established and flow measurements have been made. In the future the beneficial effects for this project may be rather accurately determined by repeating the survey as often as necessary.

It is hoped that the project may be carried to such a point that the all important abandoned mine openings may be effectively closed. If this can be accomplished the greatest stumbling block in correcting pollution from mine drainage will have been removed. The next step will be that of correcting pollution from operating mines.

Water Authority for North Jersey Supplies Proposed

Creation of a water authority having jurisdiction over all water supplies in the metropolitan area was advocated by Governor Moore in a special message to the legislature, amplifying a statement on the water situation made by the Governor five months ago.

Two bills along the lines proposed are pending. The difference is that instead of providing for one water authority, the measures would create one for the northern part of the state and the other for the southern.

Present conditions lead to but one conclusion, the Governor informed the legislature.

"Unless water supply developments are started immediately and completed with all practicable speed by the municipalities singly or by a state authority for them collectively, the northern part of New Jersey within a few years will be faced with a shortage of water, even to the extent of necessitating part time operation of industrial plants.

General features of the Governor's plan contemplates the water authority should take over the Wanaque water supply system, assuming the interest and amortization charges on all outstanding bonds issued for its construction. The water authority then would negotiate a loan, preferably federal if possible, under provision of NRA for development of a new supply, referred to by the Governor as the "second major project."

Estimates of cost submitted by the Governor indicate a new supply, yielding not less than 100,000,000 gallons a day, can be developed for $35,000,000. With the customary free grant on certain items of labor and material, the net amount of the loan necessary is placed at $31,000,000. Security for this loan under the Governor's plan would be in the form of forty-year bonds at 4 per cent interest, with one-fortieth of the total issue, or $775,000, retired each year.

Upon taking over the Wanaque supply, the water authority would set a flat rate per 1,000,000 gallons to users of Wanaque water. This would cover the cost of operating the system and the interest and amortization charges on outstanding Wanaque bonds. When interest and amortization charges become due on the federal loan for the new supply, the selling price of water would be increased to cover the added cost.

The selling price would be adjusted from year to year as might be necessary to avoid an operating deficit. Customers would not be required to guarantee any minimum amount of consumption, paying only for the amount used. This method, the Governor pointed out, would place upon users of water the total cost of collecting and delivery.

One advantage claimed by the Governor for his plan is that it would afford relief to the unemployed by immediate prosecution of a project involving the expenditure of $35,000,000, with its resulting indirect benefits to state industries.

Another advantage, equally important, the Governor said, is that municipalities which have financed the Wanaque development would be relieved of the resulting bonded debt and debt service charges, thus improving their financial standing and enabling them to carry on their strictly governmental functions with greater ease.

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TEXAS TOWNS TO REGULATE UTILITY RATES.—A bill adopted Feb. 27 by the House of Representatives of Texas gives all incorporated towns the right to regulate utility rates.

THE ATLANTA WATER SAMPLER

Simplifies Control of Operation in Filtration Practice

By PAUL WEIR[1] and J. W. ALLEN[2]

Paul Weir

RELIABLE and simplified sampling of the water during its passage through the various steps in water purification processes is conducive to accurate and efficient control of the process. It was with this in mind that satisfactory, but inexpensive Water-Samplers of the vacuum type were devised and installed at the Atlanta Filtration Plants.

At water purification plants it has often been found difficult to procure the requisite number of representative samples from various points in the plant, for the purpose of conducting tests and making comparisons of the effectiveness of each step in the process. In several instances, this has been due to the inaccessibility of source, inclement weather conditions, incorrect type of pumping equipment, limited personnel, etc. One or more of the fundamental tests, such as: turbidity, visual inspection of floc, pH, residual chlorine or chloramine, alkalinity, color, carbon dioxide, etc., should be conducted frequently at most plants, if the attainment of maximum efficiency in operating purification plants is to be realized.

This is accomplished at the Atlanta Filtration Plants

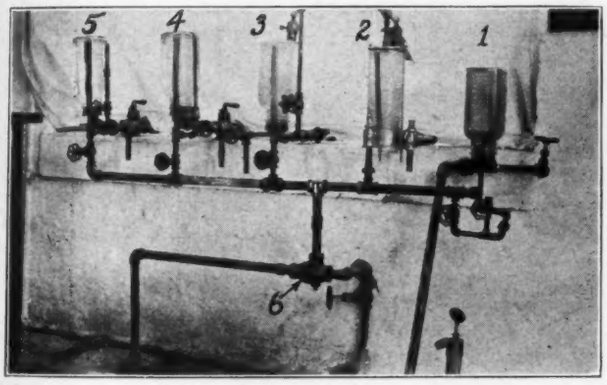

Fig. 1.—Sampler in Developmental Stage. 1—Raw Water; 2—⅓ Point of Mixing Chamber; 3—Effluent of Mixing Chamber; 4—Influent of Sedimentation Basin; 5—Effluent of Sedimentation Basin; 6—Water Ejector

by means of a series of sampling glasses, referred to as the Water Sampler, which is located in the chemical application building. (See Fig. 1.) The water flows continuously from the point of sampling through the glass inspection chember, such flow being induced by a partial vacuum created by the use of an ejector, operated from the city pressure main. There is one sampling glass connected with each desired point of sampling. A very convenient installation consists of the following arrangement: (1) Raw Water; (2) Mid Point, third or quarter point of Mixing Chamber; (3) Effluent of Mixing Chamber; (4) Influent to Sedimentation Basin (just past maximum precipitation point); (5) Effluent of Sedimentation Basin (applied water to filters); (6) Filtered Water (clear water well if obtainable).

Value of the Sampler

This arrangement constantly furnishes the operator with a progress picture of the water treatment process condensed into a space of approximately four feet. The

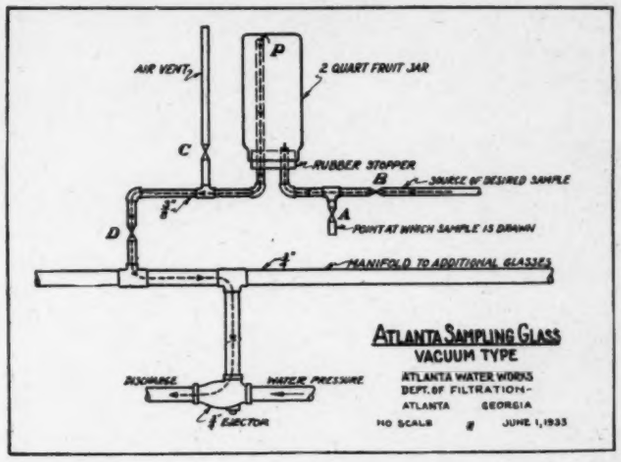

Fig. 2.—Detail Sketch Vacuum Type Water Sampler, Atlanta Filtration Plant

use of this equipment has proven indispensable in twenty-four hour operation; because, it trains each operator to readily differentiate between proper coagulation or other conditions and incorrect ones. The slightest deviation from efficient treatment can be immediately recognized and is a decisive factor in the proper and economical application of chemicals. Any variation in the quantity of applied chemical will affect the characteristic floc formation and the result appears in the sample-glass within fifteen minutes after a change; whereas, the former method of sampling required forty-five minutes. The Water Sampler also provides the visiting public with a visual (step-by-step) picture of the progress of the water purification process and indelibly impresses them with the phenomena of chemical precipitation. It has created more interest than any other feature incorporated in the plant.

Description of the Sampler

A detail sketch of the principle units comprising the Water Sampler is shown in Figure 2. The water is drawn from its source through a ¾ in. pipe line. It enters the sample glass at the bottom and flows upward to the top. An overflow line conducts it into the suction side of the water ejector, from which it is discharged to waste. This permits a small quantity of water to pass through the glass at all times and continuous, rather than intermittent, operation is decidedly preferable. There is danger of breaking up the flocculent particles in the coagulated water if too high velocity is maintained through the sampler jar. In this event, the entire purpose of the device would be lost. An optimum velocity, discharging about three quarts of water per minute,

[1]Superintendent and [2]Chief Chemical Operator, Filtration Plants, Atlanta, Ga.

closely approximates conditions in the mixing chamber and prevents precipitation in the glass.

The water to be sampled is circulated through the sampling jar by means of a vacuum, which has been created by a water ejector, attached to the overflow line leaving the glass. Square glass jars offer some advantage over round jars, due to their great plane surface, which readily reflects light through the medium and magnifies the suspended material. Glass jars of two quart capacity or less are recommended for this apparatus and the sampling glass should be placed between a source of light and the observer. This may be accomplished by locating the unit in or near a window for day time ob-

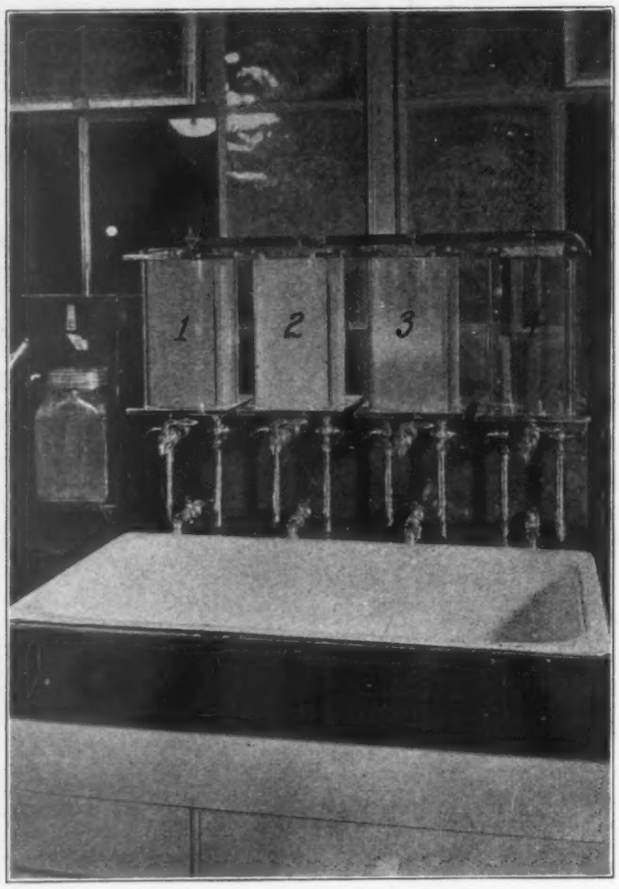

Fig. 3.—Improved Sampler. 1—Raw Water; 2—Coagulated Water; 3—Settled Water; 4—Finished Water. (On the Left Is the Machine for Making Jar Tests in Controlling Coagulant Dosages)

servation. A 60-watt frosted electric light bulb furnishes light for each sample jar during the night or when natural light is inadequate. Water ejectors of ⅜ in. size and up, may be used for procuring a maximum lift of about 20 ft. Several hundred feet of pipe may be attached to each ejector and each glass may have its own ejector or one ejector may serve an entire unit. As far as possible, abrupt angles should be eliminated from the piping of the coagulated water lines. All connection must be air tight and the use of copper pipe with streamline fittings is desirable.

Operating the Sampler

When ever a sample is desired for testing purposes, it is procured from the jar in the following manner: (See Fig. 2.)

To Start the Sampler:

1. Turn on water pressure to ejector
2. Close Valve (C)
3. Open Valve (D)
4. Close Valve (A)
5. Open Valve (B)
6. Permit to operate thus for a few minutes to build up vacuum
7. Throttle valve (D) until water barely overflows into pipe (P).

Collecting Samples from Jars:

8. Close Valve (D)
9. Close Valve (B)
10. Open Valve (C)
11. Open Valve (A) to procure sample.

Various adaptations of the water sampler have proven successful at the Atlanta plants during the past two years. Single and group units have been installed at the gravity Filtration Plant to replace worn out plunger type hydraulic sampling pumps; and, with a considerable saving in replacement cost. Filtered water samples are thus delivered into the sampling glass free from possible tap-water dilution. An accurate and reliable picture of each filter discharge is assured, thus revealing a faultly effluent from any one unit. This device also has other possibilities and should find a place in all water purification plants of the future. During the past two years similar sampling devices have been installed at other plants. (See Fig. 3.)

We wish to express our appreciation for the helpful suggestions given by W. Z. Smith, General Manager, and W. M. Rapp, Superintendent of Construction and Distribution, and others of the Atlanta Water Department.

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Illinois Water Company to Test Sales Tax Legality

A friendly suit against the department of finance of the state of Illinois to test the department's power to collect a 2 per cent occupational tax from water companies on water service furnished municipalities will be heard in the Lee County Circuit Court some time next month. A bill directed against Kenneth L. Ames, Jr., director of finance for the state, was filed with E. S. Rosecrans, circuit clerk, in behalf of the Dixon Water Company, Dixon, Ill. The bill alleges that a tax on water service furnished a municipality is illegal.

Following the enactment of a 2 per cent occupational tax by the state legislature the department of finance ruled that water service furnished by city or privately owned water companies to consumers was tangible property and therefore taxable. Objections to this ruling was filed some time ago by the local water company.

More than 3,000 customers are now receiving water service from the Dixon company for which they are paying approximately $68,000 annually, the bill states. Of this aggregate income, approximately $17,000 is paid annually by the city of Dixon for fire hydrant rental, the bill points out. This latter item is not taxable, the bill contends, as it is almost entirely a service charge.

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WATER WORKS IN OHIO.—In 1930 the Ohio Department of Health reported that 317 municipalities in the State owned water plants, of which 77 were surface supplies and 240 were well water. The surface-water plants, however, though not so numerous as those furnishing ground water, served a much larger population. Nearly 3½ million persons, or 73.3 per cent of the population using city water, were in the surface-water communities, and only 1,269,412, or 26.7 per cent, were on the ground-water supplies.

Valve and Hydrant Inspection In North Andover, Mass.

By W. B. DUFFY

Superintendent, Water Works,
North Andover, Mass.

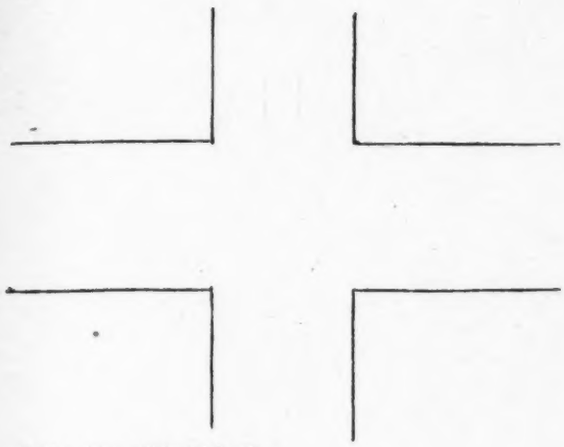
IN connection with the inspection of over 460 valves on the water distribution system in North Andover, Mass., the first step was the preparation of a location card giving dimensions from the valve boxes to hydrants, street bounds, walls, trees or other permanently visible objects. A heavy white card (4 × 6 inches) with a mimeographed typical street intersection and directions for inspecting the valve was used. (See Fig. 1.) A small wooden cabinet was used for filing these.

With a very small permanent personnel and over 50 miles of water mains in a town of 7,000 people, gate inspection work was necessarily carried on by two regular water department men, with a truck, in the early

Gate Inspection

Size
Location

Plan



Gate Box Visible?
Gate Box Clear?
Oil Stem
No. Turns to close?
Condition of Gate?

Date

Fig. 1—Gate Valve Inspection Card

spring and late fall when other construction work and repairs permitted.

The gate inspection card called first for the finding of the gate which in our town with unimproved streets and rural highways required the use of the measured location tres and of a box finder. Valve box adapters were used to bring the box to the surface where a good road surface was had and the box covered not over 6 inches. Otherwise covered boxes had to be dug and raised to the surface.

Diluted automobile crankcase drainings were poured down the valve key stem as a preliminary to shutting and opening the gate. The use of oil to lubricate the packing in this manner proved effective in relieving some hard turning valves that had not been operated for years. The number of turns to close each valve was counted and recorded. Valves on dead ends which would cut off the supply were not fully closed. The condition in which the valve was found was recorded. The number of valves not in condition to be closed at once, those not fully open and valves found shut in some cases, demonstrate the need of the annual inspection of all valves.

Photostatic copies of these locations were subsequently made on tracing cloth from which blue prints were made for future use.

Hydrant Inspection Routine

As a preliminary to the inspection of over 300 fire hydrants in North Andover, Massachusetts, 4 × 6 inch inspection cards were mimeographed listing the location and kind of hydrant, the static pressure and eight items of inspection as shown on the inspection card. (See Fig. 2.)

The statics pressure only was first recorded. The location and condition of the gate on the hydrant branch were then noted. The gate box was cleared if necessary. The hydrant having been first shut off, an aquaphone was used to discover any leakage. If the hydrant did not drain properly the hydrant valve was opened with the nozzles caps on and very often this cleared away the obstruction. A great many of the older hydrants required new rubbers on the drip valve. Occasionally the hydrant valve required a new rubber to replace one which had become worn. The stem was oiled and the nozzle caps graphited for easy removal. A great many hydrants required the stuffing boxes to be packed, for which purpose a graphited metallic asbestos fiber packing was used after removing what was left of the old flax packing.

Hydrant Inspection

Location

Kind

Pressure

1 Hydrant Gated?
2 Gate Clear?
3 Hydrant Leaking?
4 Drip Working?
5 Hydrant valve close properly?
6 Oil Stem
7 Graphite Caps
8 Paint

Remarks:

Date

Fig. 2—Hydrant Inspection Card

The last inspection item called for hydrants with a gate on the hydrant branch to be painted with a high visibility yellow enamel for the body and black enamel for the nozzles caps and top. Hydrants without gates were painted yellow and with the tops and nozzles caps red.

By authority of a town by-law which restricts the use of fire hydrants to the fire department, both the street department and the tree warden are required to return a record card to the water department every time they use a fire hydrant. Small 3 × 5 inch cards were mimeographed with the space for the date, location of hydrant, opened by whom and condition of the hydrant. This means of restricting the use of the hydrant by unauthorized persons has been successful.

Green colored hydrant inspection cards are used for the ungated hydrants and white cards for those with gates, thus distinguishing the installations at once in our small vertical filing cabinet. The information required on the green cards is the same as that on the white cards.

EDITORIALS

Chemists Who Pay Their Way

THAT ferric coagulants bid fair to attract more attention in water purification practice, seems evident when one considers modern developments in the manufacture and application of iron salts.

The article by L. C. Billings, appearing elsewhere in this issue, which relates the successful use of ferrous sulphate oxidized with chlorine (chlorinated-copperas) at the Dallas, Texas, filtration plant, deserves attention. This, not because the use of chlorinated-copperas, and other ferric salts, is new in water purification practice; but, because, contrary to general impressions of chemists, a ferric iron compound has proven superior and more economical in alkaline coagulation (pH 8-9) and for turbidities up to 3,000 P.P.M., than had ferrous sulphate assisted by aeration and the application of lime. The last combination having heretofore been considered to be the least costly of the processes of coagulation, where this method proved suitable for the water encountered. The Dallas water is a semi-hard water and, one subject to difficult clarification because of the nature and quantity of turbidity it carries at times. The treatment at Dallas is more in the nature of partial softening than mere coagulation, as is indicated when examining the ratio between lime applied and coagulant dosage. Under such circumstances, the more novel and surprising becomes the observation that about one-half as much oxidized (chlorinated) copperas is required in comparison with that found necessary when ordinary copperas was being employed.

Mr. Billings in commenting on the results at Dallas, calls attention to the fact that coagulants in greater variety, at comparable prices, are now available than has been the case in former years; and, therefore, renewed thought and study could profitably be given to the selection of the particular coagulant, or coagulants, which appear most effective and economical in the treatment of the waters being dealt with at various purification plants. He points out that the recent successful adaptation of ferric compounds in sewage treatment has directed particular attention to the possibilities of this type of coagulant. In connection with his latter comment, it is interesting to observe that history repeats—viz: that ferric salts were used as coagulants in sewage clarification before ferric chloride was used so successfully by Duyk in 1902 as the coagulant at Belgian filtration plants.

Ferric salts were used experimentally by the late Allen Hazen at the Lawrence, Mass., Experimental Station for both water and sewage, but their use proved to be far less economical than sulphate of alumina, i.e., filter alum. Later a method of coagulation, developed by Bull, involved the passage of chlorine and water through a tower filled with scrap iron. Whether, because impractical, too costly, or both, the Bull (patented) scheme did not find favor—but, interestingly, came to light within recent years as a scheme used, in chlorination practice, in an attempt to unsuccessfully avoid infringement of the Ornstein chlorination patents.

Following the shelving of Bull's process, ferrous sulphate and lime came into some prominence in the water purification field; but, so far as ferric coagulants were concerned, there was quite a gap of time between Bull's invention and the use of ferric salts experimentally by the Chicago Sanitary District in 1925 for coagulation of sewage sludge for denaturing by mechanical filtration. The, then available, ferric-salts, proved uneconomical for practical usage, and the production of home-made ferric chloride was likewise too expensive because of the cost of the chlorine involved. Here, necessity again proved to be the mother of invention and a search by Palmer and Mohlman for a source of a cheaper ferric iron compound in 1926 led to the oxidation of inexpensive ferrous sulphate with chlorine; and, thereafter, the practical large scale production of a novel coagulant, dubbed "chlorinated-copperas." In difficulty with other methods of coagulating sewages, the use of "chlorinated-copperas" was promptly tried and adopted at the Houston Texas; and shortly after at the Milwaukee, Wis., activated sludge plants. Ferric-chloride has since been produced at a cost to compete with chlorinated-copperas and therefore has established its place; except, that the cost of long freight hauls often renders prepared ferric-chloride (f.o.b. consumer's plant) more expensive than chlorine and copperas required to produce equivalent results, or an equal weight of ferric iron at point of consumption.

As a new coagulant, chlorinated-copperas caught the attention of L. L. Hedgepeth, then Superintendent of Filtration at Elizabeth City, N. C., who like Mr. Billings, was on the lookout for the most efficient coagulant for the conditions at hand. Not to dwell on the problem which presented in its early stages, difficult angles and near failures at times, suffice it to say here, the process, in Mr. Hedgepeth's hands, proved successful in the end and Elizabeth City, N. C., went down in history as the first city (1927) to use chlorinated-copperas as a water coagulant—where, it has been continued to date. It was later used at Chickasaw, Ala., and thereafter at other points also, but with less evident benefits. Providence, R. I., with a soft, colored and manganese bearing water adopted chlorinated-copperas after thorough trial and represented, for a time, the largest city to use it. More recently a prepared ferric-sulphate from a nearby source has since appeared on a competitive (delivered) price basis to displace copperas and chlorine at Providence.

Not to overlook the economy of home-made ferric-chloride in competition with chlorine and copperas or ready prepared ferric salts, it is timely to point to the practice at Oklahoma City, Oklahoma, where scrap iron is converted to ferric-chloride by a continuous process involving an upward-flow of chlorine water through a tank filled with scrap, the overflow from which is further treated with an auxiliary continuous additional chlorine, to completely oxidize the ferrous chloride content of the liquor. In this process the iron dissolved is a function of the chlorine applied and therefore the primary chlorine feed device is calibrated in terms of pounds of chlorine and, also, in terms of equivalent pounds of iron being discharged (per 24 hours) in the form of ferric coagulant.

A "New Deal," pertaining to coagulation practices and economies, as in other matters, seems to be in order. Mr. Billings has timely, and properly, called attention to the advisability of renewed investigations, looking to the choice of coagulants and practices best suited for existing conditions, under the new circumstances. In his case he added 1 part per million of chlorine; used 9 parts less of coagulant; got better results—and, what's more, is saving $4,000 per year in treatment costs. In this day, when it is so difficult to hold water treatment costs within the budget, Mr. Billings must have gotten a deal of satisfaction from his accomplishments.

The ? in Sludge Digestion—To Mix or Not to Mix?

As pointed out in the article by C. E. Keefer, on another page in this issue stirring, by recirculation, produces increased gas yields from sludge; but, the practice appears to have both good and bad features. The sludge drawn was not inferior because of inferior digestion; but, it had one serious deficiency, viz., a higher moisture content as compared to that from the quiet (non stirred) twin tank used as a control. Dr. Rudolfs in discussing Mr. Keefer's findings, at Baltimore, before the New York Sewage Works Association, made a point of the seemingly small and unimpressive difference in water content of the two sludges. But, he said, that slight difference had been responsible for a 50 per cent greater volume of sludge drawn from the circulated tank than from the quiescent tank, when handling equal weights of solids. This constitutes an important and highly practical objection to too vigorous stirring of contents of digesters. On top of this undesirable feature the solids passing out in the supernatant liquor renders too rapid or too continuous stirring of digesters a questionable practice. The heat losses from the heated tank did not increase with the stirring operation as many had anticipated might be the case and the scum depth was reduced thereby.

When one compares the good and bad points of stirring sludge in single stage digestion tanks, it is necessary to inquire—why should there not be a combination effect which will prove overall of high desirability. That is to say—What is there but merit to a stage digestion scheme, wherein the primary digestion can be conducted in heated tanks, equipped with agitators or recirculating devices similar to the Pruss pump or the Simplex Aerator, used in activated sludge plants, followed by secondary quiet digestion to completion in larger but less expensively equipped tanks which will serve also as sludge storage tanks. The foul, problem creating, supernatant liquor, if any, from the primary tank would pass to the secondary tank, mixed with sludge or scum. The supernatant liquor of low solids content would, thereby, issue from the secondary tank to be disposed of by admixture gradually with the crude sewage during the maximum practical number of hours. Sludge of highest practical solids content and lowest volume would issue from the secondary tanks—the latter to be thoroughly insulated but not equipped for heating since heat input will be represented by that transferred along with the drawings from the primary tanks. To complete the picture each stage should be tied into a gas holder of some sort to increase the flexibility of operations and insure the continuity of power production from the gas if used for that purpose.

When one sums up the benefits of heating and stirring, for speeding digestion, eliminating pH correction and reducing volume requirements in sludge digestion, against the shortcomings of foul supernatant liquor and increased sludge volume, it seems apparent that a combination of rapid mixing and quiescent digestion has many features which merit greater thought than has been given such a scheme. The claims by advocates of stirring, and also by those favoring normal (quiescent) digestion, will then have been satisfied. The gas holder in the system will serve as an important fuel reservoir and safety device of no slight value.

Sludge digestion and its ultimate disposal is by no means a closed chapter in modern sewage treatment practice. The larger plants may dispense with digestion in favor of mechanical denaturing of raw sludge and incineration or fertilizer production. The smaller ones stand fair to be dependent upon digestion for some time to come. The value of sludge gas for power production makes it less likely that digestion will be entirely eliminated at even the larger works, even though the degree be reduced appreciably. It behooves sewage men to look further into sludge digestion improvements and economics.

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Cold Weather and Water Supply Problems

COLD weather brings more difficulty and hazard to water supply practice than is commonly appreciated. Aside from the unprecedented freezing up of fire hydrants and mains, meters and services during such protracted and severe weather, as has been experienced in the East and Northeast during the present winter, there is the danger of blockage of intakes with needle ice and other hazards to be considered.

A method of detecting the onset of and a satisfactory means of overcoming intake ice troubles were related in an article in the February issue of WATER WORKS AND SEWERAGE by Carl Leipold, of Winnetka, Ill., which has proven to be practical, inexpensive and dependable. In this issue an experience, with another and important cold weather hazard, is recited in an article by Horace A. Brown, Supt. of Water Works at Ottumwa, Ia., in which he states that sewage bacteria in the untreated sewage from the 150,000 people of Des Moines, Ia., had traveled 90 miles down the ice covered river to the Ottumwa intake—"as if through a refrigerated pipe line from Des Moines to Ottumwa." The cold weather had reduced the flow in the river and the deep ice had restricted the flow section possibly to the point where increases in velocities caused bottom sludge scouring. In any event, at a time when organisms remain virulent and purification processes are at lowest efficiencies, this condition resulted in a loading on the purification plant represented by bacterial counts of over 6 billion per c.c. in the raw water—a hazard of no small consequence.

Further, the dissolved oxygen content, at the time, reached the low of 4.2 parts per million, indicative of biological activity in the absence of reaeration and consequent oxygen depletion. Under parallel circumstances ice-cover has cut off oxygen supply from polluted streams elsewhere to bring about oxygen depletion, killing of fish and production of severe odor and taste troubles due to the products of anaerobic break down of organic compounds. An outstanding case of this sort was that at Toledo, Ohio, a few years ago when the Maumee River remained frozen over for some time.

The algae, Synura, is one of the most powerful producers of taste troubles in impounded supplies. Unfortunately, it is one of the "winter organisms" and causes trouble when lakes are covered with heavy ice, making application of algaecides difficult if not impossible. New York City has in fact had to cut holes in the ice to apply copper-sulphate at times in past years. With the thick ice covering of the present year, it is possibly of great importance that the New York Department of Water Supply practices chlorine and copper-sulphate application continuously to the water as it enters its more troublesome reservoirs. Instances are reported wherein the ice thickness on lakes has, this winter, been too great for its practical harvesting—30 to 38 inches. Synura and other organisms which pester the life of the water works men never had a safer existence than they experienced this winter.

Among cold weather troubles, freezing up of streams and ice jams have caused threatened shortage of water.

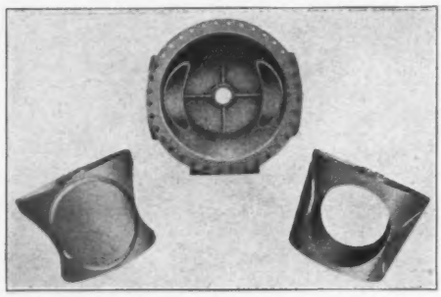
NEW EQUIPMENT AND MATERIALS

The "Rotovalve"

The S. Morgan Smith Company of York, Pa.—a company new, perhaps, in the municipal field, but backed by 55 years of experience in the design of large turbines, pumps, rotary and plug valves in the hydro-power field—have recently entered the municipal field with the "Rotovalve."

These new valves are particularly designed to serve in the water and sewage field as altitude, pressure regulator, and automatic check valves.

The chief advantages of the "Rotovalve" are: (a) its flush passage-way (throughout its length) equal to the full area of pipe connection, resulting in minimum head loss; (b) 3 point bearings, which permit "exact" alignment of the valve plug and body, to insure continuous and certain case of operation; (c) reseating of these valves in open position; (d) interchangeable parts; (e) gradual and positive functioning of automatic features



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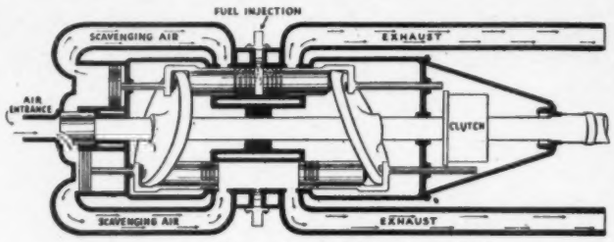
to prevent water hammer and surge. Further—the opening and closing time can be independently controlled in automatic operation. "Rotovalves" are offered for manual, or automatic, hydraulic or electric operation in sizes 6 to 48 inches for pressures up to 800 pounds per square inch.

The economic importance and operating value of such valves in pumping stations was stressed in the interesting and enlightening "Report of the Committee on Water Supply Engineering" presented before the A. S. C. E. in January, and reported in digest form on page 59 of the February issue of WATER WORKS AND SEWERAGE. Water Works Managers and Engineers should find the new and informative brochure—"Rotovalves"—worthy of examination. For a copy address: S. Morgan Smith Company, York, Pa.

▼

Sterling Crankless Diesel Engine

Sterling Engine Company of Buffalo, N. Y., announce a revolutionary engine which is the first crankless Diesel engine to be built. The 2 cycle engine having no crankshaft or camshafts, no cylinder heads, no valves or cylinder head gaskets, is materially reduced in weight and is of extremely compact construction. It runs on the lowest grade of fuel oil and the predicted fuel cost is estimated at 75 per cent less than the cost of fuel for a gasoline engine of equal power output. Depending upon size, the weight of the new



Interior Diagram of Operation of the Sterling Crankless Diesel

engine ranges from 13 to 20 pounds per horse power as against 50 to 80 pounds in the conventional Diesel. The absence of many conventional parts has reduced vibration and noise, maintenance care and expense. The pistons traveling horizontally contribute to smoothness of operation, longer service and reduced height of engine. The engine starts more positively than a gasoline engine and accelerates rapidly and uniformly. It incorporates the simplest movements yet designed in an internal combustion engine. In this development of a prime move with greater range of speeds (from 200 r.p.m. to maximum); freedom from vibration; flexibility of control, the goal of Diesel engine designers has been more closely reached than ever before.

This new type engine will find a place in the municipal field for operating electric generators, centrifugal pumps and air blowers where ordinary Diesels, gas or gasoline engines have heretofore served.

For descriptive literature or further information, address Sterling Engine Company, Buffalo, N. Y.

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WITH THE MANUFACTURERS *Pen-Chlor Acid-Proof Cement and Brick*

The Pennsylvania Salt Manufacturing Company, through its subsidiary, Pen-Chlor, Inc., Philadelphia, have just announced the new acid-proof "Penchlor" cement and bricks for use in constructing tanks or pipe lines to store and transport the most corrosive chemical solutions or chlorine. The cement is quick setting, has a compressive strength of 2400 lbs. and tensile strength of 350 lbs. per sq. in. It adheres to stoneware, rubber, metals, wood, concrete or glass and is especially useful in connection with storing and transporting ferric chloride and chlorine—the most corrosive chemicals used in water and sewage plants.

For literature, address: Pen-Chlor, Inc., Widener Building, Philadelphia.

Ralph A. Stevenson Establishes His Own Business

Ralph A. (Steve) Stevenson, formerly Chemist and Superintendent of the Sacramento filtration plant and for the past two and one-half years Research Engineer for the Great Western Electro-Chemical Company of San Francisco, resigned January 1st to enter business for himself as a jobber of a complete line of chemicals used in water and sewage treatment.

Mr. Stevenson has taken over the distribution and sales of Great Western ferric chloride and is representing several other manufacturers of chemicals used in the sanitary field.

He enters the commercial field with a wide and thorough knowledge of the applications of chemicals in sanitary problems. And a feature stressed in his new undertaking is "Technical Service with Sales."

"Steve," we wish you great success in your new venture. His office is at 514 East Eighth St., Los Angeles, Calif.

▼

Johns Manville Issues Municipal Engineering Series of Booklets

Johns Manville have recently compiled facts, figures and specifications covering J.-M. products used in construction and operation of public utilities. This material is being presented in the form of a series of new booklets, now ready for distribution by the company. Those of especial interest to readers of WATER WORKS AND SEWERAGE, with a brief summary of contents, are:

"Pumping Stations"—Packings; insulation; flooring and roofing.

"Filtration Plans and Reservoirs"—Transite pipe; waterproofing materials; Celite for concrete.

"Distribution Systems"—Transite pipe; underground pipe protection.

"Sewage Treatment Plants"—Transite pipe; packings; wall board; flooring and roofing materials; asphalt floor tile; waterproofing materials; Celite; noise and heat insulation; boiler and pipe insulation; refractory cements.

"Municipal Light and Power Plants"—Covers a large group of J-M materials.

Transite piping especially treated to conduct corrosive chemical solutions on chlorine is covered in a separate booklet not listed above.

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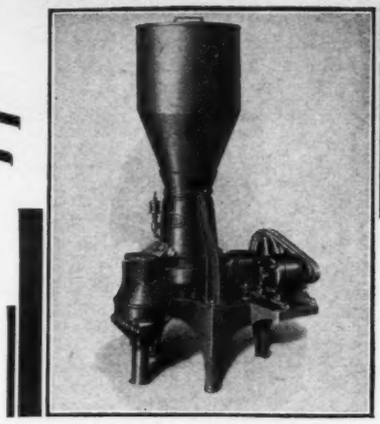

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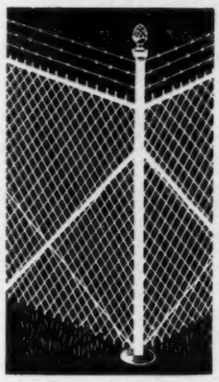

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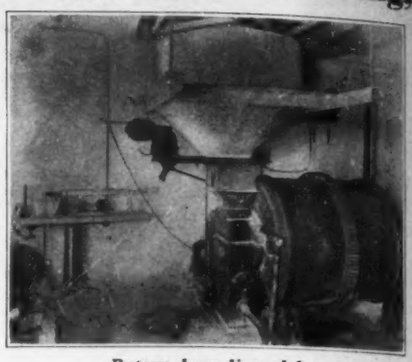

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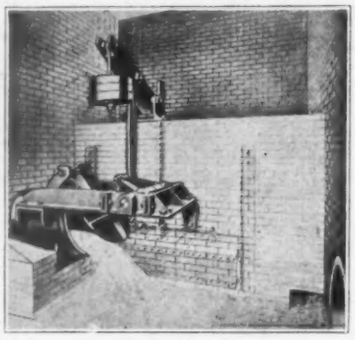

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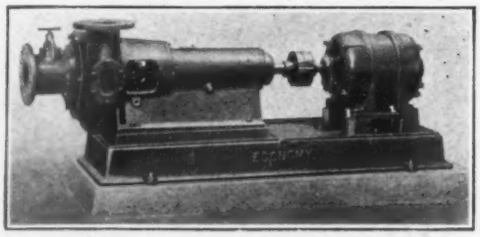

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CHEMICAL ENGINEER—B. S., University of Denver, Denver, Colorado. Age 25; married; excellent health. Experienced in inorganic analysis. Best references. Location and nature of work immaterial. Available immediately. Address M. G., % Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

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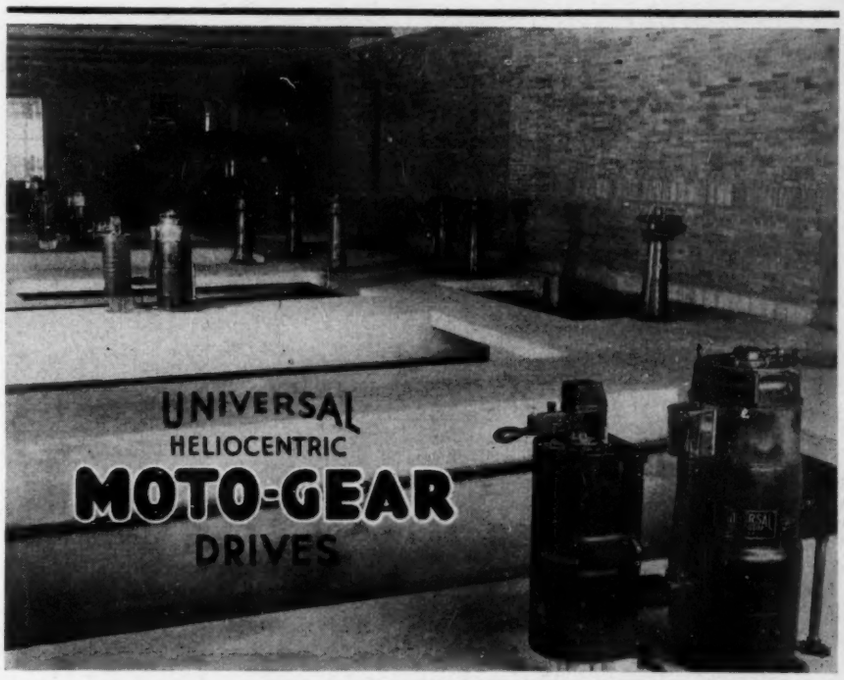

Above: Four Universal Drives in Wilmette Filtration Plant—600 to 1 reductions built integral with 2-H.P. 4-speed motors—Pearse, Greeley & Hanson, Engineers; E. W. Bacharach & Co., Contractors. Below: Four of eight Universal Drives in Fort Wayne Plant—72 and 1,000 to 1 ratios. Hoad, Decker, Shoecraft & Drury, Engineers; Roberts Filter Mfg. Co., Contractors.

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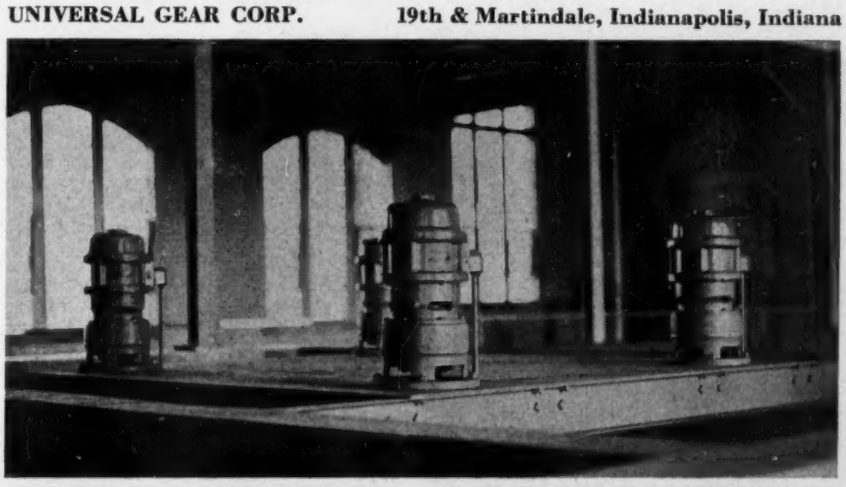

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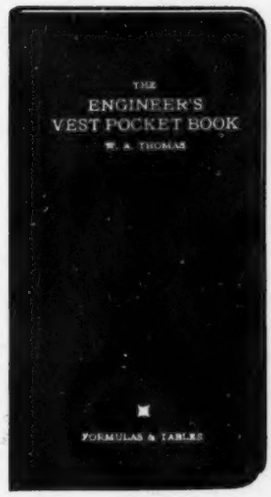

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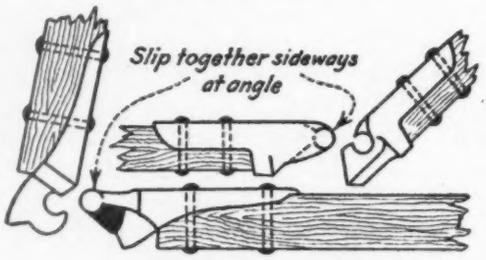

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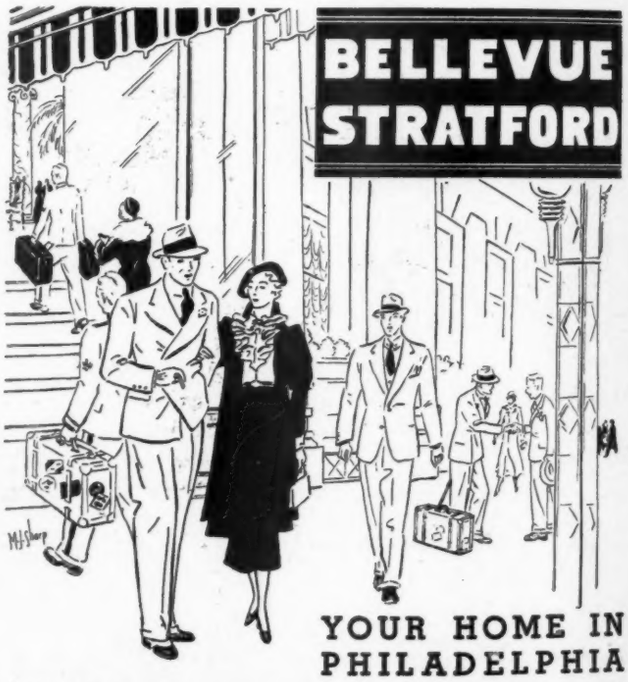

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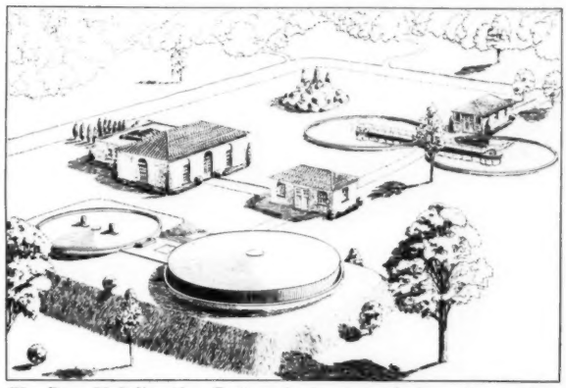

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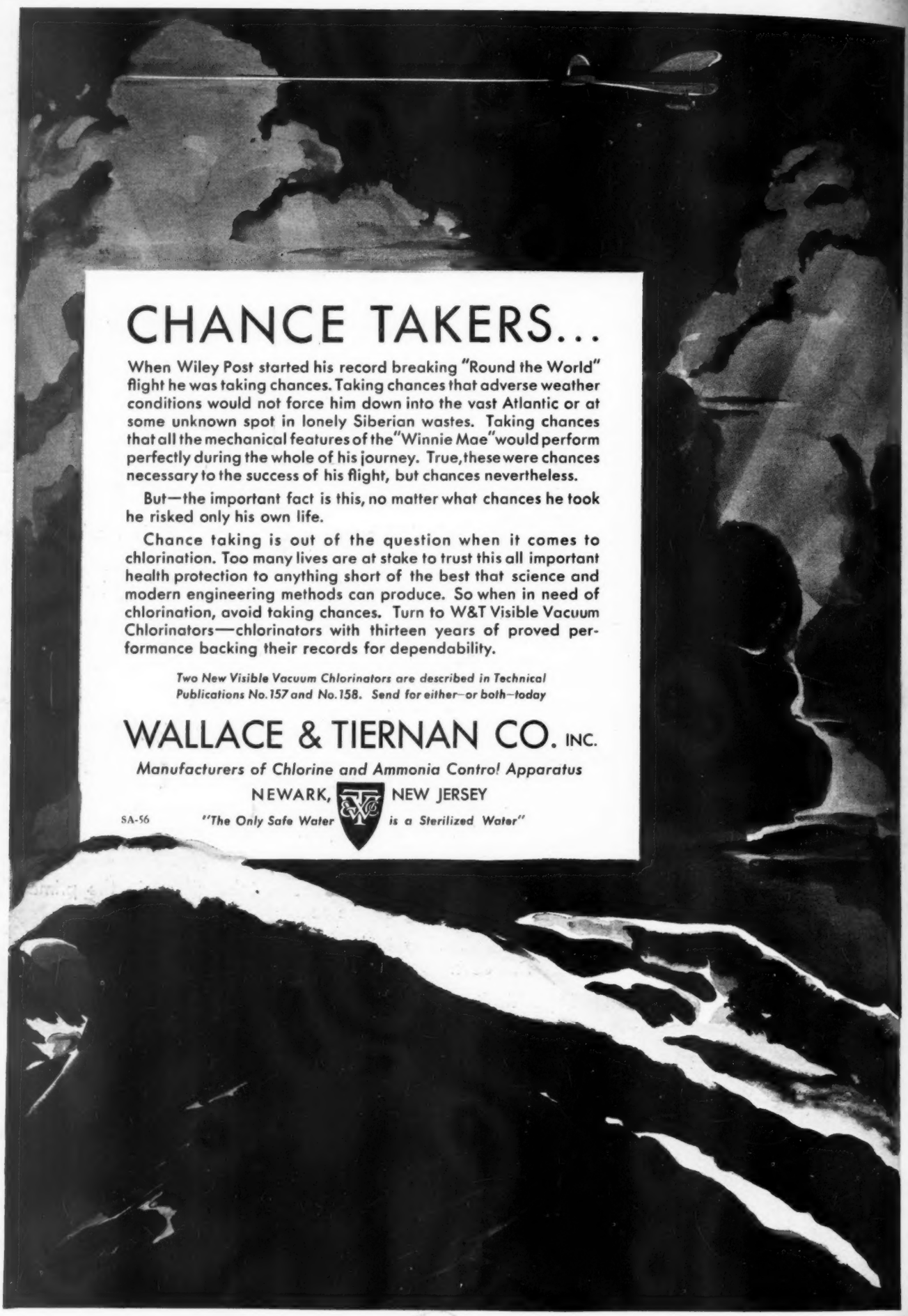

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